PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS.

(INSTITUTED 1852.)

VOL. XXVIII. No. 6.

AUGUST, 1902.

Edited by the Secretary, under the direction of the Committee on Publications.

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NEW YORK 1902.

American Society of Civil Engineers.

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The House of the Society is open from 9 A.M. to 10 P.M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

HOUSE OF THE SOCIETY—220 WEST FIFTY-SEVENTH STREET, NEW YORK.

TELEPHONE NUMBER, - - - - 533 Columbus.
CABLE ADDRESS, - - - - - "Ceas, New York."

Vol. XXVIII. AUGUST, 1902. No. 6.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

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SOCIETY AFFAIRS.

CONTENTS:

MINUTES OF MEETINGS.

OF THE SOCIETY.

THIRTY-FOURTH ANNUAL CONVENTION, HELD AT WASHINGTON, D. C., MAY 20th, 21st, 22d and 23d, 1902.

Opening Session, Tuesday, May 20th, 1902.—The meeting was called to order at 10 A. M. by Mordecai T. Endicott, M. Am. Soc. C. E., Chairman of the Committee of the Board of Direction on the Annual Convention.

The Chairman introduced the Hon. H. B. F. Macfarland, President of the Board of Commissioners of the District of Columbia, who, in a brief speech, welcomed the Society to the national capital. The Chairman then introduced Rear Admiral George W. Melville, Hon. M.

Am. Soc. C. E., Chairman of the Local Committee of Arrangements, who, in behalf of the local members, extended a hearty welcome to the Members of the Society and their guests.

The President, Robert Moore, M. Am. Soc. C. E., then took the chair, and introduced Chas. Warren Hunt, Secretary, Am. Soc. C. E., who presented a sketch of the history of the Society during its first fifty years.

General William P. Craighill, Past-President, Am. Soc. C. E., moved that a telegram of congratulation be sent to Mr. Robert B. Gorsuch, the first Secretary of the Society, and who, according to Mr. Hunt's report, is the only survivor of those who founded the Society in 1852. The motion, duly seconded, was carried unanimously.

The following message was sent:

"Washington, D. C.,
"May 20th, 1902.

"Robert B. Gorsuch,
"Mexico City.

"The American Society of Civil Engineers, by unanimous vote in Annual Convention, tenders kind greetings and good wishes to Robert B. Gorsuch, the sole survivor of its founders.

"Chas. Warren Hunt,
"*Secretary.*"

Subsequently, this reply was received:

"Mexico City,
"May 21, 1902.

"Chas. Warren Hunt,
"*Secy., American Society of Civil Engineers,*
"Washington, D. C.

"Your kind greetings on behalf of the Society of which I had the honor of being one of its founders brings overwhelming recollections of ambitious effort now a pleasure tempered with sadness. Proud of having been one of the initiators of so eminent a scientific society, please tender my highest appreciation to its members for their thoughtfulness on the occasion mentioned.

"R. B. Gorsuch."*

The President then delivered the Annual Address.

The Secretary presented letters from the Director, U. S. Geological Survey, offering facilities for the inspection of Methods of Survey, etc., and transmitting 500 copies of the Topographic Map of Washington and Vicinity; from the President of the Capital Traction Company, tendering free transportation during the four Convention days; from the Commandant, Washington Navy Yard, stating that he had arranged to put a jacket on a 12-in. gun during the visit of the Society to the Yard on the 21st; from the Secretary of the Navy, acknowledging an invitation to attend the Convention; from the Secretary of the International Association for Testing Materials, inviting Members to attend the Fifth

* These messages are here interpolated to preserve the record in convenient form.

Annual Meeting of the American Section, June 12th–14th, 1902; and from the Secretary of the Cosmos Club, extending the courtesies of the Club to members of the Society during the Convention.

A resolution, introduced by Bernard R. Green, M. Am. Soc. C. E., inviting the local officers of the Corps of Engineers of the Army and Navy, Civil Engineers of Washington, not members of the Society, and the Washington Chapter of the American Institute of Architects, to attend the meetings of the Convention was seconded and carried unanimously.

David S. Carll, M. Am. Soc. C. E., explained the arrangements which had been made in reference to free transportation over the lines of the Washington Railway and Electric Company during the Convention, and in reference to the excursion to Cabin John Bridge.

Colonel William M. Black, M. Am. Soc. C. E., extended an invitation to visit Washington Barracks and witness the guard mounting and dress parade of the Engineers' School and Battalion, and announced further details in reference to the excursion to Fort Washington, Marshall Hall and Mt. Vernon on Thursday, May 22d.

Adjourned.

Second Session, Tuesday, May 20th, 1902.—The meeting was called to order at 8 P. M.; the President, Robert Moore, in the chair; Chas. Warren Hunt, Secretary; many members and guests being present.

Talks, descriptive of engineering works in Washington, and illustrated with lantern slides, were given, as follows:

On District Government, by Colonel William M. Black, M. Am. Soc. C. E.

On the Washington Sewers, by D. E. McComb, M. Am. Soc. C. E.

On the Water Supply of Washington, by Colonel A. M. Miller, M. Am. Soc. C. E.

On the Washington Monument and Library of Congress, by Bernard R. Green, M. Am. Soc. C. E.

On the Electric Railways of the District, by D. S. Carll, M. Am. Soc. C. E.

On Proposed Park Improvements in the District, by Charles Moore, Esq.

Adjourned.

BUSINESS MEETING.

Third Session, Wednesday, May 21st, 1902.—The meeting was called to order at 10.30 A. M.; President Robert Moore in the chair; Chas. Warren Hunt, Secretary.

The Secretary presented the report of the Committee on the

desirability of action being taken for the protection of engineers and the public from incompetent practitioners.*

On motion, duly seconded, the report was accepted and adopted.

H. G. Prout, M. Am. Soc. C. E., presented the report of the Committee on a Proposed Amendment to the Constitution Relative to Admission to Membership.†

On motion, duly seconded, the report was received and placed on file.

William P. Craighill, Past-President, Am. Soc. C. E., presented the following resolution:

"*Resolved*, That the Board of Direction be requested to frame an amendment to the Constitution which shall do away with the secret letter-ballot now used in the election of corporate members, and substitute therefor an open or signed ballot."

The resolution was duly seconded, and, after discussion, was withdrawn by the proposer.

The Secretary presented a report of the votes received as to the Time and Place for holding the Annual Convention of 1903.‡

After discussion, it was moved that:

"The matter of the time and place for the Annual Convention of 1903 be referred to the Board of Direction, with the statement that it is the sense of this meeting that it shall be held in Asheville, N. C."

The motion, being duly seconded, was carried.

The Secretary reported a recommendation from the Board of Direction that the Special Committee "On Analysis of Iron and Steel," Subcommittee of the American Society of Civil Engineers (of the International Committee on Standards for the Analysis of Iron and Steel, of which Professor J. W. Langley is chairman), be discharged.

On motion, duly seconded, the Committee was discharged.

The Secretary reported that the Board of Direction recommends that the Special Committee "On Units of Measurement" be discharged.

On motion, duly seconded, the Committee was discharged.

Adjourned.

Fourth Session, Wednesday, May 21st, 1902.—The meeting was called to order at 8 P. M.; President Robert Moore in the chair; Chas. Warren Hunt, Secretary.

Discussion on the following topic was called for by the President:

"In contract work, either public or private, is it preferable to make separate contracts for the different branches of trades involved, or to combine all under one general contract?"

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* See page 198.

† See page 197.

‡ See page 208.

The discussion was opened by George E. Gifford, M. Am. Soc. C. E., and was continued by the following:

T. Chalkley Hatton, M. Am. Soc. C. E.
Charles G. Darrach, M. Am. Soc. C. E.
S. Bent Russell, M. Am. Soc. C. E.
M. Ward Easby, M. Am. Soc. C. E.
Charles Worthington, M. Am. Soc. C. E.
Horace Andrews, M. Am. Soc. C. E.

The meeting then took up the discussion of the second topic, as follows:

"Is it possible and desirable to keep accounts of work in progress in such a manner as to ascertain unit costs on each class of work?"

The Secretary presented the opening discussion, prepared by S. Whinery, M. Am. Soc. C. E., and the subject was further discussed by the following:

Charles S. Churchill, M. Am. Soc. C. E.
T. Chalkley Hatton, M. Am. Soc. C. E.
Oberlin Smith, M. Am. Soc. C. E.
Charles Worthington, M. Am. Soc. C. E.
Foster Crowell, M. Am. Soc. C. E.

The meeting then took up the discussion of the third topic, as follows:

"Is steel susceptible of being made as permanent a building material as masonry?"

The discussion was opened by Charles G. Darrach, M. Am. Soc. C. E., and was continued by the following:

E. W. Stern, M. Am. Soc. C. E.
George F. Swain, M. Am. Soc. C. E.
C. C. Wentworth, M. Am. Soc. C. E.
Oberlin Smith, M. Am. Soc. C. E.
William R. Webster, M. Am. Soc. C. E.
Charles G. Darrach, M. Am. Soc. C. E.
James Owen, M. Am. Soc. C. E.
E. T. D. Myers, Jr., M. Am. Soc. C. E.
John F. O'Rourke, M. Am. Soc. C. E.
W. Hildenbrand, M. Am. Soc. C. E.
H. S. Haines, M. Am. Soc. C. E.
A. L. Johnson, M. Am. Soc. C. E.

The Secretary read a telegram from Mr. Robert B. Gorsuch, in reply to the message of good wishes sent to him during the First Session of the Convention.*

Adjourned.

* For text of messages exchanged, see page 170.

Fifth Session, Thursday, May 22d, 1902.—The meeting was called to order at 8 P. M.; President Robert Moore in the chair; Chas. Warren Hunt, Secretary.

The President called for discussion on the fourth topic, as follows:

"In view of the numerous disasters caused by the contracting of channels, or the damming of small streams, should non-navigable streams be under the control of the National Government?"

The discussion was opened by Rudolph Hering, M. Am. Soc. C. E., and was continued by the following:

L. M. Haupt, M. Am. Soc. C. E.
A. M. Miller, M. Am. Soc. C. E.

The meeting then took up the discussion of the fifth topic, as follows:

"Should the National Government undertake the construction and operation of irrigation works?"

Elwood Mead, M. Am. Soc. C. E., opened the discussion, which was continued by the following:

T. M. Ripley, Assoc. M. Am. Soc. C. E.
F. H. Newell, M. Am. Soc. C. E.
George H. Maxwell, Esq.
J. James R. Croes, Past-President, Am. Soc. C. E.
L. M. Haupt, M. Am. Soc. C. E.

The meeting then took up the discussion of the sixth topic, as follows:

"Should Engineering Practice be regulated by a code of ethics? If so, how can such a code be established?"

George A. Soper, Assoc. M. Am. Soc. C. E., opened the discussion.

Adjourned.

Sixth Session, Friday, May 23d, 1902.—The meeting was called to order at 10 A. M., President Robert Moore in the chair; Chas. Warren Hunt, Secretary.

The discussion on the sixth topic was continued by the following:

John A. Ockerson, M. Am. Soc. C. E.
Benjamin M. Harrod, Past-President, Am. Soc. C. E.
J. James R. Croes, Past-President, Am. Soc. C. E.
F. W. Dalrymple, Assoc. M. Am. Soc. C. E.
George A. Soper, Assoc. M. Am. Soc. C. E.

Written discussions on this subject by Charles G. Darrach, M. Am. Soc. C. E., and by W. Hildenbrand, M. Am. Soc. C. E., were also presented.

Chas. Warren Hunt, M. Am. Soc. C. E., presented the following resolution:

"*Resolved*, That the hearty thanks of the Society are hereby tendered to the Local Committee for the great care with which the arrangements for the comfort and pleasure of members and guests have been planned, and the masterly manner in which those plans have been carried out."

The resolution, being duly seconded, was carried unanimously.

A. Mordecai, M. Am. Soc. C. E., moved that the Board of Direction be requested to have a tree planted at Mt. Vernon, or make some suitable commemoration of the visit of the Society.

The motion, duly seconded, was carried.

Bernard R. Green, M. Am. Soc. C. E., moved as follows:

"That the thanks of the Society be extended for the courtesies received from the various organizations and departments here in Washington during this Convention: To the Secretary of War, for the courtesies at Fort Washington and the Washington Barracks; to the Secretary of the Navy, for the courtesies at the Navy Yard; to Dr. Wolcott, of the Geological Survey, for the maps freely given to the Society; to the Capital Traction Company for the free transportation upon its lines during the Convention to all the members and guests of the Convention; to the Washington Railway and Electric Company for the free cars on the occasion of the visit to Cabin John Bridge; and to the Trustees of the Corcoran Gallery of Art for the free use of the Gallery and the courtesy of their invitation to the Society to meet the friends of the Society in Washington at the gallery this evening."

The motion, duly seconded, was carried unanimously.

Adjourned.

June 4th, 1902.—The meeting was called to order at 8.45 P. M.; Emil Kuichling, Director, Am. Soc. C. E., in the chair; Chas. Warren Hunt, Secretary; and present, also, 80 members and 13 guests.

The minutes of the meeting of May 7th were approved as printed in *Proceedings* for May, 1902.

A paper by George L. Dillman, M. Am. Soc. C. E., entitled "A Proposed New Type of Masonry Dam," was presented by the Secretary, who also presented a written discussion by H. de B. Parsons, M. Am. Soc. C. E. The paper was discussed orally by Messrs. Edward Wegmann, Robert Cartwright, George H. Pegram, A. V. Abbott, J. Breuchaud, W. B. Fuller and Emil Kuichling.

Ballots for membership were canvassed, and the following candidates were elected.

As Members.

Charles Hinckley Baker, Seattle, Wash.
Frederic Adrian Delano, Chicago, Ill.
James Albert Emery, Birmingham, Ala.
Xanthus Henry Goodnough, Boston, Mass.
Stephen Harris, Philadelphia, Pa.

Julius Merriam Howells, Los Angeles, Cal.
Owen Lovejoy Ingalls, Washington, D. C.
Jeremiah Joseph Kennedy, New York City.
Luther Yager Kerr, Greenville, Miss.
Anson Burlingame McGrew, Beaver, Pa.
Clarence Rufus Neher, Buffalo, N. Y.
Michael Maurice O'Shaughnessy, San Francisco, Cal.
Augustus Smith, New York City.
Otto Hilgard Tittmann, Washington, D. C.
Edward Chandler Tollinger, Greenville, Miss.
Thomas Henry Tutwiler, Birmingham, Ala.

As Associate Members.

John Edwin Banks, Pittsburg, Pa,
Louis Edward Bogen, Cincinnati, Ohio.
Alfred Ellsworth Carter, Havana, Cuba.
Clarke Peleg Collins, Johnstown, Pa.
James Rhea Fain, Philadelphia, Pa.
Sumner Gowen, Phœnixville, Pa.
William Kendrick Hatt, Lafayette, Ind.
William Herbert Hyde, Pittsburg, Pa.
Charles Hamilton Mitchell, Niagara Falls, Ont., Canada.
Frederick Charles Noble, New York City.
Thomas Dorsey Pitts, New York City.
Charles Abner Ruggles, New York City.
John Kimball Scammell, St. John, N. B., Canada.
William Seaton, Jr., Rosebank, N. Y.
Charles Milton Spofford, Boston, Mass.
Arthur Webster Thompson, Cumberland, Md.
Frederick Eugene Turneaure, Madison, Wis.

The Secretary announced the election of the following candidates by the Board of Direction on June 3d, 1902.

As Member.

Arnold Henry Sutermeister, Albany, N. Y.

As Associates.

Henry Julius Kaltenbach, Yonkers, N. Y.
Alfred Liebmann, New York City.
Houston Lowe, Dayton, Ohio.
Fred Lincoln Stearns, New York City.

As Juniors.

Bertrand Faugères Bell, Chillicothe, Ohio.
Samuel Allen Cobb, Muskogee, Ind. T.
Albert Howard Horton, Detroit, Mich.
Richard Denny Parker, Palestine, Tex.
Ralph Fennu Proctor, Detroit, Mich.
Charles Lucas Wachter, New York City.

The Secretary announced the death of the following members:

William Shattuck Lincoln, elected Member Dec. 5th, 1883; died May 16th, 1902.

Edward Josiah Blake, elected Member April 3d, 1889; died May 29th, 1902.

Robert Henry Temple, elected Member May 6th, 1885; died December 23d, 1901.

Adjourned.

OF THE BOARD OF DIRECTION.

(Abstract.)

May 21st, 1902.—The Board met, as required by the Constitution, during the Annual Convention, Washington, D. C.; President Moore n the chair; Charles Warren Hunt, Secretary; and present, also, Messrs. Croes, Endicott, Kuichling, O'Rourke, Pegram and Seaman.

No quorum being present, the meeting adjourned.

June 3d, 1902.—Vice-President Schneider in the chair; Charles Warren Hunt, Secretary; and present, also, Messrs. Briggs, Croes, Endicott, Kuichling, Pegram and Seaman.

The report of the Nominating Committee was received.

The Secretary reported the receipt, through the U. S. Commission to the Paris Exposition of 1900, of a Diploma and of a Bronze Medal awarded to the Society for its exhibit.

Action was taken in the matter of having a tree planted at Mount Vernon, Va., commemorative of the visit of this Society to the home of Washington on May 22d, 1902.

Reconsideration ballots were canvassed and Arnold Henry Sutermeister was declared elected a member of the Society.

Applications were considered and other routine business transacted.

Four candidates for Associate and six for Junior were elected.*

Adjourned.

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* See pages 176 and 177.

REPORT IN FULL OF THE FIRST SESSION OF THE THIRTY-FOURTH ANNUAL CONVENTION, INCLUDING THE BUSINESS MEETING, HELD AT THE WILLARD HOTEL, WASHINGTON, D. C.

Tuesday, May 20th, 1902, 10 A. M.

MORDECAI T. ENDICOTT, M. Am. Soc. C. E.—Ladies and gentlemen: It devolves upon me, as Chairman of the Committee of the Board of Direction in general charge of the Convention, to call this, the 34th Annual Convention of the American Society of Civil Engineers, to order, which I now do. Meeting Convened.

Distinguished gentlemen are here to greet you to the National Capital, and without further words, I take pleasure in introducing to you the Hon. H. B. F. Macfarland, President of the Board of Commissioners of the District of Columbia.

HON. H. B. F. MACFARLAND.—Ladies and gentlemen: We are very glad to see you here. We are giving you a warm welcome, even though we have to force the season a little to do it. We wanted you to have a taste of the typical Washington summer, a little warm, but breezy. We always have these delightful breezes—up here—(laughter), and to give you the sense of being at home, as you think of the warmer climates from which so many of you come. Here in this hall, looking out from these windows, you get the inspiration of the Washington surroundings, which, in itself, furnishes a reason for your being here. Addresses of Welcome.

The Government of the District of Columbia is especially glad to welcome this Society, on its semi-centenary, to the National Capital, for this National Society, with its international membership, representing, as I understand, every continent and all the great isles of the sea, has, through many of its members, rendered important services to the National Capital. We recognize to-day not only the appropriateness of your meeting in the Capital of the country, which in the fifty years since your Society was founded has been distinguished by your achievements, but a feeling of gratitude on the part of the citizens of the District of Columbia for what you have done here.

The City of Washington might be said to be, of all the cities in the world, the work of engineers. George Washington, father not only of his country, but of its capital, who, as a boy leaving school forever for the university of life, made his first money and his first reputation as a surveyor and engineer, whose name the Federal City inevitably bears, Pierre Charles L'Enfant, the brilliant Frenchman, and Andrew Elliott, the brilliant American—these are the names that immediately arise in our minds as we think of the beginning of the permanent seat of government of the United States.

Addresses of Welcome (continued).

Washington, more entirely than any other city in the world, not excepting St. Petersburg, I suppose, was designed throughout on engineers' plans, and was built up in conformity with them. Its convenience, its healthfulness, its beauty, are due largely to the fact that during the many years when the District of Columbia had no executive government, and no general development of the original plan of improvements was carried on, engineers were busy usefully here. They constructed the Washington aqueduct, they built buildings, they built bridges. Since 1878, when the permanent executive government of the District was established, the National Capital has been most fortunate in having the only complete engineering department, manned throughout by engineers, to be found, I suppose, anywhere.

Much of the success of the present form of government is due to the fact that all engineering and construction work has been in charge of engineers of high character and capacity. As a citizen of the District, only temporarily in office, I am glad to acknowledge the great debt which we citizens of the United States owe, and which the people of the whole country, whose capital this is, owe to the honest, intelligent and efficient men who have successively served as engineer commissioners and assistants to the engineer commissioners of the District of Columbia. They have, without exception, maintained the high reputation of the Corps of Engineers of the United States Army, and they have, in many cases, won the personal and lasting regard of the people of the District. I can speak from intimate knowledge of their work of recent years, beginning with that of former Commissioner Black, and I want to say that it commands my hearty admiration. These distinguished army officers have had the assistance of a permanent staff of civil engineers gathered through years of careful selection, which is not, I venture to say, excelled by any similar body of men anywhere in the world; appointed, retained and promoted on merit alone. Encouraged and stimulated by every honorable incentive, these men have done and are doing remarkable work.

Throughout nearly a quarter of a century, the Engineering Department of the District of Columbia has had a shining reputation for honesty and efficiency, and deserves and has received the confidence and appreciation of all that is best in our citizenship. Other engineers completed the Washington Monument and built the Library of Congress, and still others have cared for the beautiful parks that you see all around you. Indeed, you behold the monument of engineers wherever you look around in the District of Columbia. You, of all men, will appreciate what they have done and also all that is planned to be done in the development and embellishment of that Capital which every American wants to see the finest in the world. (Applause.)

THE CHAIRMAN.—I take pleasure in introducing the Chairman of the Local Committee in charge of this Convention, Rear-Admiral George W. Melville, who will now address you. (Applause.)

Rear-Admiral George W. Melville, U. S. N., Hon. M. Am. Soc. C. E.—Mr. President and Gentlemen: The Local Committee of Arrangements, in behalf of the resident members, extends a cordial welcome to the American Society of Civil Engineers in convention assembled. Your presence in this city also affords satisfaction and pleasure to the resident members of the allied engineering organizations. There are in the District of Columbia over one thousand graduates of technological institutions. The local alumni, of practically every scientific college in the country, recognize the fact that the benefits accruing from your deliberations will result to the advantage and enlarged prestige of the engineering profession, and therefore give you an earnest greeting.

It was thoughtful action which determined the selection of the Capital City as a place for your Annual Meeting, for Washington is, in fact, if not in name, an engineering center. It is true that the public at large has not heretofore regarded this city as such a center of technical influence. Nevertheless, the recognition of engineering as a profession has been due in great part to the scientific problems solved at the National Capital. It has only been because the engineering influence of this city has been overshadowed by its executive and legislative environments that Washington's importance as respects engineering has not been better appreciated and understood.

In at least four of the Executive Departments, the Engineer, whether or not this is his title, directs the professional work of many of the leading bureaus. As for the War and Navy Departments, the line separating the work of the military and naval officer from that of the engineer is very indistinct. In the design and mount of a gun, in the laying out of fortifications, in the building of docks, in the construction of a battleship, in the transportation of troops and supplies, and in the management of arsenals and naval stations, engineering executive ability of a high order is required.

Numerous excursions have been projected for your personal pleasure and professional profit. These trips are of such varied nature that you will better realize the important part that devolves upon engineering in the conduct of administrative affairs. If time will permit you to make careful investigation, you will be strikingly impressed with the fact that, so far as the future is concerned, the estimation in which engineering is held by the National Congress may determine the scope of the influence which will be exerted by the profession throughout the country at large.

It is in this city where many of the most imposing buildings in America can be seen, and the design of these edifices is the product of the mind of an engineer, for surely the architect can be regarded as an engineering specialist.

One of the best appointed and most complete gun foundries in the world will be open to your inspection, and one need have but a cur-

Addresses of Welcome (continued).

sory knowledge of the principles underlying the mechanic arts to understand that the ordnance expert could accomplish little if he were not an engineer.

During your visit to the Navy Yard you will be shown the experimental basin or model tank for determining many questions relating to naval architecture and marine engineering. In some respects this experimental tank is unrivaled by any in the world. It should be of incalculable benefit to the study of naval architecture and marine engineering, if operated under the supervision of the National Engineering Societies in conjunction with naval experts.

The various Executive Departments will also tell of the engineering opportunities presented to the profession, and of the necessity for our members to keep in touch with the professional work done at the Capital. The more time that is given to a study of the work of these departments, the greater will appear the necessity for all the engineering associations to meet oftener in convention in this city. There is a wealth of professional literature in the libraries of the various Executive Departments that can only be appreciated by the resident members. Rare and valuable books have been collected with judgment and discretion, and these professional works are accessible to every engineer. The technical libraries at the National Capital are well indexed, and in no city ought the engineering student find more opportunities and encouragement for original research.

The National Congress, in its investigation of hundreds of bills that are introduced each session, calls for technical and engineering opinions that require a high order of professional intelligence to answer. Probably the greatest tribute that could be paid to the work and worth of the engineering profession lies in the fact that, in both Houses of the Congress, the belief prevails that the report of a Board of Engineers is the carefully considered opinion of experts of integrity and efficiency.

Heretofore, the engineering profession has labored under the impression that Washington was a place where legal, medical, religious and political conventions should be held, but a city whose environments were not compatible to an assembling of engineers. It has been to the material disadvantage of the profession at large that this opinion should prevail. The unrivaled press organizations that are in existence in this city give particular attention to reporting the proceedings of all national associations. The professional treatises that will be read at the meeting, with the attendant discussions, will thus be telegraphed daily and be brought to the attention of the members of the Society throughout the country.

One of the many beneficial results that will be secured from your visit will be the fact that it will direct the attention of other engineering associations to the advantages of doing work of a national character. The scope and character of the work of the engineer will never receive the recognition that is its due until the executive officers of the

Government and the members of the National Congress fully realize the amount of study and practical experience that is necessary to fit one for professional engineering work. If the various engineering associations will frequently meet here, and if we can assemble an Engineering Congress in Washington every ten years, it will not be long before the country will realize the scientific depth and breadth, as well as the vital import and universal scope, of engineering work. If study, reflection, preparation, experience and character are the factors requisite for national leadership, then engineering has a claim to high recognition in bringing about national progress and prosperity.

It has been said that five elements are essential to the performance of great purposes: Time, place, opportunity, incentive, and the man. The Committee are to be congratulated in having secured two of the essential factors for a successful convention. At this period of the year the city appears at its best, for the atmospheric conditions are not only favorable to professional work, but also for that broad observation which should be acquired by every well-rounded professional man. It is also an opportune time by reason of the fact that the National Congress is in session, and the Capital City is filled with influential personages from all parts of the country. The character and nature of your work should be brought to the attention of such persons, since they are the ones who dominate national affairs. It has been a weakness upon the part of the engineering profession in the past that the various associations have held their annual conventions in places where it has been impossible for the national feature of our work to be brought into prominence.

The engineer was a dominant factor during the past hundred years, although he was neither accorded the honor, nor received the rewards of his achievements. It is highly probable that his influence will be even greater in the present century. In the future there awaits him the recognition which is his just due. With such incentives as the recognition of the world at large for his professional achievements, and substantial rewards for the accomplishment of great enterprises, it can be expected that men will come to the front who will honor themselves and their profession, and render the world a great service in accomplishing engineering feats which will surpass those of the last century. Gentlemen, we welcome you. (Applause.)

The President Introduced.

The CHAIRMAN.—We will depart from the line marked out here, for the purpose of introducing, before the history of the Society is read, our President, Mr. Robert Moore, who will address you.

ROBERT MOORE, President, Am. Soc. C. E.—Mr. Chairman, in taking the chair to which you have called me, I know I express the sentiments of every member of the Society, as well as of our guests, in expressing my thanks and appreciation for the words of welcome and the deeds of welcome which those words foreshadow, which you have heard from those who have welcomed us this morning, and I cannot help

Addresses (continued).

expressing my very high appreciation of the thoughtful skill which the gentleman has indicated on the part of the Committee in furnishing to us, who come from the cool summer resorts of the middle West, a brilliant example of true home weather. And much more than this, as has been indicated, makes us feel at home in Washington. It is truly a city of which engineers may well feel proud, bearing as it does, the name of one who was not only the father of his country, but one whose name the city bears, and whom we are also glad to recognize as a fellow member of our profession. We, therefore, as citizens of the United States, feel also as citizens of Washington, and I am sure that, after the addresses that we have heard, we will also feel that, for the time at least, it is our home. Again I wish to express to you our hearty appreciation and thanks for your welcome. (Applause.)

The Board of Direction has thought it wise to recognize the fact that this is the semi-centennial of the Society by putting first in the order of exercises a sketch of the history of this, our beloved Society, and I therefore take pleasure in calling to the stand Mr. Charles Warren Hunt, who will give you a brief outline of the first fifty years of the life of the American Society of Civil Engineers. (Applause.)

Charles Warren Hunt, M. Am. Soc. C. E., then addressed the Convention on the history of the Society.*

GEN. WM. P. CRAIGHILL, Past-President, Am. Soc. C. E.—Mr. President, I have arrived at the age when I sympathize with old men, and I discover from this very interesting address that one of the original members of the American Society of Civil Engineers is still living in the City of Mexico. It seems to me that it would be proper that we should send to him a telegram of congratulation, and I make that motion. (Applause.)

The motion, being duly seconded and put to vote, was unanimously carried, and the Secretary was instructed to send a telegram in accordance therewith.

The President then delivered the Annual Address.†

Programme of Convention.

The SECRETARY.—The programme, I think, everybody has seen, and, as far as the Secretary knows, that programme will be carried out as printed, except that there will be a few slight modifications which will be mentioned by members of the Local Committee who are present.

I would like to read one or two letters.

Letters.

"PHILADELPHIA, Pa., May 19th, 1902.

"Mr. C. W. HUNT,

"*Secretary, American Society of Civil Engineers*,

"Willard's Hotel, Washington, D. C.

"DEAR SIR,—The Fifth Annual Meeting of the American Section of the International Association for Testing Materials will be held at the Hotel Traymore, Atlantic City, on June 12th, 13th, 14th. Numerous

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* *Transactions*, Am. Soc. C. E., Vol. xlviii, p. 220.

† *Transactions*, Am. Soc. C. E., Vol. xlviii, p. 227.

papers on the physical and chemical properties of the materials of engineering will be presented at this meeting by recognized authorities, and certain features of the Standard Specifications for Steel Rails adopted by this Society will be taken up for further discussion.

"The Executive Committee desires to extend a cordial invitation to the members of the Committee on Rails, and to any other members of the American Society of Civil Engineers, interested in these subjects, to attend this meeting and to participate freely in the discussions. Copies of the programme will be gladly furnished on application to the Secretary.

"Very truly yours,

"EDGAR MARBURG,

"*Secretary.*"

"WASHINGTON, D. C., May 19th, 1902.

"CHARLES WARREN HUNT, Esq.,

"*Secretary, American Society of Civil Engineers,*

"Washington, D. C.

"SIR,—The Capital Traction Company takes pleasure in extending to the members of the American Society of Civil Engineers, and their guests, in attendance upon the Annual Convention, held in this city during the four days, May 20th to 23d, inclusive, free transportation over the lines of its system, the only requirement being the wearing of the official badge of the Convention in full view while on the cars of the company.

"Yours very truly,

"G. T. DUNLOP,

"*President.*"

"WASHINGTON, D. C., February 10th, 1902.

"MR. CHAS. WARREN HUNT,

"*Secretary, American Society of Civil Engineers,*

"220 West Fifty-seventh Street,

"New York City.

"DEAR SIR,—My attention has been called to the recent meeting in this city of the local membership of the American Society of Civil Engineers; also of the proposed convention of the Society to be held in Washington in May next, and it has been suggested by members of the Society connected with the Geological Survey that an opportunity should be offered to the visiting members during the convention to inspect the different branches of the Survey which may be of interest to civil engineers.

"The geologic work, as related to mining; the topographic survey, its methods and maps; the engraving on copper and printing from the stone of maps in colors; the hydrographic work, bearing upon the water resources of the country, and methods of stream measurement, are all features which will doubtless be of interest to members of the Society, and I take pleasure in offering such facilities of inspection as may seem to be best suited to the occasion, as may hereafter be determined upon by the Committee.

"Yours, with respect,

"CHAS. D. WOLCOTT,

"*Director.*"

Letters (continued)

"WASHINGTON, D. C., May 17th, 1902.

"*To the Secretary of the American Society of Civil Engineers,*
"Washington, D. C.

"SIR,—I take pleasure in sending to you herewith five hundred copies of the topographic map of Washington and vicinity for distribution to the members of your Society at your annual convention to be held in this city.

"Very respectfully,
"CHAS. D. WOLCOTT,
"*Director.*"

"WASHINGTON, D. C., May 19th, 1902.

"MR. CHARLES WARREN HUNT,
"*Secretary, American Society of Civil Engineers.*

"DEAR SIR,—I beg to tender to members of your Society visiting Washington, as well as resident members, an invitation to visit the Capitol Building. Directions will be given to the various heads of departments, under my supervision, to extend to members every courtesy within their power. It will give me great pleasure to meet personally any who desire to call at this office.

"Very truly yours,
"ELLIOTT WOODS,
"*Supt., etc.*"

"COSMOS CLUB,
"WASHINGTON, D. C., May 20th, 1902.

"MR. CHARLES WARREN HUNT,
"*Secretary, A. S. C. E.,*
"The New Willard Hotel,
"Washington, D. C.

"MY DEAR SIR,—The Board of Managers of this Club wishes to extend the courtesies of the Club to the members of your Society during the time of the present meeting.

"Yours very truly,
"L. O. HOWARD,
"*Secretary.*"

"COMMANDANT'S OFFICE,
"UNITED STATES NAVY YARD,
"WASHINGTON, D. C., May 19th, 1902.

"DEAR MELVILLE.—Thanks for the invitation to be the guest of the Society of Civil Engineers this week. I find in the programme a visit to the Navy Yard, Wednesday afternoon, and for the entertainment of the visitors we have arranged to put a jacket on a 12-in. gun, about 2.30 that day. We had intended to do this to-day, but postponed it to Wednesday that members of the Society might see it.

"Hastily yours,
"TERRY."

BERNARD R. GREEN, M. Am. Soc. C. E.—I want to introduce a resolution, but prior to that I want to say that the Local Committee understands there may be warmer weather this week, and, therefore, a less suitable time is coming to put the jacket on that gun. (Laughter.)

They need a great deal of heat, however, for that purpose.

As a member of the Local Committee, I beg to offer the following resolution:

"That the officers of the Corps of Engineers of the United States Army—the local officers—the local officers of the Corps of Engineers of the United States Navy, the civil engineers of the city, not members of this Society, and the Washington Chapter of the American Institute of Architects, be invited to attend the meetings of this Convention." Invitations.

The resolution, being duly seconded, was carried unanimously.

DAVID S. CARLL, M. Am. Soc. C. E.—The Secretary has read the letter of the President of the Traction Company. A number have asked what lines the Traction Company operates. They operate the cars running on Pennsylvania Avenue, out 14th Street, out 7th Street, and out to the Zoological Park. There is a map of the whole system in the rear of the hall. On that map the lines of the Traction Company are shown by heavy dotted lines. I wish further to call your attention to the excursion this afternoon to Cabin John Bridge. The programmes are wrong, and if you will look at the head of the list of members you will find that it says, "through the courtesy of the Washington Traction Company." It should be "the Washington Railway and Electric Company." It also says that the cars will be waiting in front of the Ebbitt House. Now, the cars can't wait, although it says that they can, because there is a three-minute service on the road, which they must maintain, but there will be plenty of cars there for all who want to go to Cabin John Bridge, through the courtesy of the Washington Railway and Electric Company.

WILLIAM M. BLACK, M. Am. Soc C. E.—Ladies and gentlemen, there is something that may be an attraction for some of you which is not down on the programme. The Engineers' School and Battalion is stationed at Washington Barracks, and it says on the programme they will give you a pontoon bridge-building drill on Thursday morning. In addition to that, I wish to state that every evening of this week, except Thursday and Saturday, there will be a regular guard mounting, concert and parade, beginning at five o'clock. Guard mounting at five o'clock sharp, concert, and then dress parade at half-past five every evening, and we would like to see you down there. Take Pennsylvania Avenue cars and change at Seventh Street. That takes you down to the Post.

DAVID S. CARLL.—Free.

MR. BLACK.—Mr. Carll says free, but if you take the other line on F Street and then change at the corner of 9th and F Streets, that line will also take you down to the gates of the Post, going down 9th Street, and we would be very glad to see any of you. As I said, guard mounting is at five o'clock, band concert immediately after, and dress parade at half-past five. The Secretary desires me also to say that, the Convention being unexpectedly large and the excursion unex-

Invitations (continued). pectedly popular, we will have to make a slight change in the excursion on Thursday, to this extent: Marshall Hall can only accommodate 500 persons, so that the tickets, which will include the dinner on Thursday, will be limited to 500, and those who haven't them may not get them, because there are only about 120 left. However, there will be, in addition to that, 200 tickets at 75 cents each, which will not include the dinner, but anyone getting a 75-cent ticket will be able to buy a small lunch on the boat. The boat is large enough; simply the accommodations at Marshall Hall for planked shad are limited.

There being no further business, the meeting was adjourned.

BUSINESS MEETING.

Business Meeting Convened. **Wednesday, May 21st, 1902.**—The meeting was called to order at 10.30 A. M.; President Robert Moore in the Chair; Chas. Warren Hunt, Secretary.

THE PRESIDENT.—Gentlemen, this being the Annual Business Meeting, a very important meeting in the affairs of the Society, we will proceed to business. The first thing on the programme is a report of the Committee, appointed at the Niagara Convention, on the desirability of action being taken for the protection of engineers and the public from incompetent practitioners.

Report of Committee on Regulating Practice of Engineering.

The Secretary read the report as follows:

REPORT OF THE COMMITTEE ON REGULATING THE PRACTICE OF ENGINEERING.

TO THE AMERICAN SOCIETY OF CIVIL ENGINEERS:

The Committee authorized by the last Annual Convention, and appointed by the President, to consider and report upon the advisability and practicability of regulating the practice of Engineering, with the object of excluding incompetent persons from practice, begs leave to present the following report:

In the prosecution of its work the Committee made an effort to collect information relating to what has already been done, or attempted, to regulate the practice of the profession in this and other countries, and also to learn, as far as practicable, what has been done by other professions and by some trades toward regulating their practice, and a brief synopsis may be of interest.

So far as the Committee is advised, there exist no laws in the United States regulating or limiting the practice of Engineering in any of its branches, with the exception of the Architects' law mentioned later. Efforts have been made in a few States to secure the enactment of such laws, but without success.

In Canada the subject has been agitated for a number of years, with the result that acts relating to Civil Engineers have been passed

in the Provinces of Quebec and Manitoba. These acts are quite similar in their essential requirements. The Quebec law, which was approved January 15th, 1898, after reciting in the preamble the fact of the incorporation of the Canadian Society of Civil Engineers, and declaring that it is desirable to establish the qualifications necessary to authorize persons to practice as Civil Engineers in the Province, enacts that, after January 1st, 1899, no person shall be entitled to use the title of Civil Engineer or to practice the profession unless he shall be, or shall become, a member of the Canadian Society of Civil Engineers. It defines the qualifications necessary for admission to the Society, and the conditions of membership. A board of examiners is constituted, consisting of six persons, four of whom shall be named by the Council of the Society, and one each by McGill University and Laval University. This Board shall meet at least twice each year to examine candidates who may apply for admission to the Society either as students or as corporate members. Those admitted as students may be, after passing a later prescribed examination, admitted as corporate members. In either case the applicant must pay in advance of the examination the entrance fees to the Society. Persons who pass the advanced examination receive a diploma, and become, without further action on the part of the Society, corporate members.

The act prescribes that no by-law that may be adopted by the Society shall have force or effect until approved by the Lieutenant Governor of the Province. The practical effect of the law is to make corporate membership in the Canadian Society of Civil Engineers the condition upon which the profession may be practiced in the Province. Exception is made in the case of persons authorized to practice by previous legislation. Persons not thus authorized to practice cannot recover before any court or justice any sum of money for civil engineering services, and they are liable to a fine not exceeding $25 for assuming or using the title of Civil Engineer or of membership in the Society.

The Manitoba Act, approved March 19th, 1899, after referring more in detail to the organization and management of the Canadian Society of Civil Engineers, closes with a section (17), as follows:

"On and after the 1st day of July, 1896, no person shall be entitled within this Province to take or use the name and title of 'Civil Engineer' or any abbreviation thereof, either alone or in combination with any other word or words, or any name, title or description implying that he is a member of the said Society of Civil Engineers, or act as Engineer in laying out, advising on, constructing or superintending the construction of any railway or public work, or any work upon which public money is expended, the cost of which shall exceed $500, unless such person is a member of the Society hereby incorporated and registered as such under the provisions of this Act, or unless he is a duly qualified Civil Engineer, and entitled to use the title of Civil

Report of Committee on Regulating Practice of Engineering (continued).

Engineer by virtue of some statute in force in this Province, or by the authority of some institution of learning in this Province having authority to confer degrees in Civil Engineering, or unless he has been practising as a Civil Engineer in this Province at the time of the passing of this Act, or unless he is a member in good standing of some Institution of Civil Engineers in Great Britain and Ireland, or of some National Society of Civil Engineers of good standing in any foreign country."

It will be noted that while the leading provisions of this Act are quite similar to those of the Quebec Act, it is somewhat more liberal, since it exempts persons practicing Civil Engineering at the time the act was passed, as well as members of National Societies of Civil Engineers, and those upon whom the degree of Civil Engineer may be conferred by institutions of learning. The Act provides no penalty for its violation. Efforts have been made to secure the passage of a similar law by the Provincial Parliament of the Province of Ontario, but so far without success, an act very similar to the Quebec Act having been rejected at the last session of the Parliament.

These Canadian measures have not been in force long enough to afford a practical test of their value, particularly as no serious attempt has yet been made to enforce them rigorously. It seems to be felt that such enforcement must await the adoption of similar legislation in the other Provinces, and that they must, for the present, be regarded as little more than educational in character.

Mexico has a system of licensing Engineers that possesses, in theory at least, some meritorious features. In the regular course of introduction to practice, all candidates for professional pursuits must take the prescribed course of study in the official Government schools, which are organized and conducted upon something like the same lines as the military and naval academies at West Point and Annapolis. Candidates for the profession of Engineering must spend the last year of the course of study in the field upon some public work in course of construction. The Government makes provision for this by inserting in all Government concessions and contracts a clause requiring the concessionaries or contractors to provide for the reception of these students upon their work, a salary or allowance sufficient for their support being provided by the Government. The students must study the practical features of the work with which they are connected, and must prepare drawings and reports upon the same, which they must present for their final examination at the end of the year. If they pass this examination successfully they receive their "title" or diploma, which authorizes them to practice the profession in any part of Mexico. Persons, either native or foreign, not graduates of the Government schools, may be granted similar titles to practice, by passing a prescribed examination, among the requirements for which are a knowledge of the Spanish language, and the presentation of drawings of

works with which they have been connected. Graduates of technical schools, other than those of the Mexican Government, and members of foreign engineering societies are entitled to enter these examinations. The law does not, however, prohibit professional practice by those, whether native or foreign, who do not possess Government titles or licenses, but all plans, reports, etc., which require the approval of the Government, all Government land surveys and all engineering documents to go before the courts, must be signed by a titled engineer. In practice, however, it is stated to be quite usual for such work to be done by untitled engineers who then secure the signature of a titled engineer, though he may not have had any other connection with the work, or may be employed by the untitled engineer in some subordinate position. Whatever opinion may be held as to the practical utility of the system, it undoubtedly confers upon the profession a certain degree of dignity and standing that would otherwise be wanting.

The Committee has not been able to ascertain that any provision exists in European countries for the licensing of engineers or for the regulation of professional practice except in so far as such regulation may be brought about by the civil service examinations in force in most of these countries. In governmental work the graduates of official technical schools are required to perform certain duties, and they enjoy certain advantages, but no restriction is placed upon the general practice of the profession by any who may choose to engage in engineering work.

Correspondence with engineers in England, Germany and France indicates that in their opinion no legal regulation of practice has been found necessary or is thought desirable.

With the exception of the Ministry, practice in all the professions other than Engineering is regulated by law in nearly all the States of the United States, and, while we cannot attempt to go into detail, it may be well to refer in a general way to what has been done in these other professions.

It is a noteworthy fact that as a rule the most stringent measures and the highest standard of requirements are found in the older and more completely developed States, and that the standard of preparation and proficiency required, as well as the penalties prescribed for practicing without proper authorization, have been advanced materially in recent years.

In the Law, regulations governing admission to the Bar are in force in all the States and Territories. The States of New York and Illinois may be taken as examples of the latest and most advanced requirements in that profession.

In New York, applicants for admission to the Bar must undergo a formal examination before a Board constituted for the purpose. In

Report of Committee on Regulating Practice of Engineering (continued).

addition to a good general education, the applicant must satisfy the Board that he has pursued the study of Law for at least three years, and must pass an examination upon legal subjects selected by the Board. In Illinois, similar requirements are made as to a good general education and three years' study, and the examination covers all the leading branches of the law. This examination is so severe that there are many failures to pass, even by graduates of law schools.

Attorneys from other States are admitted upon affidavit that the course of study pursued by them was equal to that required in the State, that they were regularly admitted to the Bar, and that they have practiced two full years.

In the Medical profession there has been a marked increase in the requirements, though there is great diversity in those of the different States. New York requires a candidate to have a general education equivalent to a good high-school course; to have studied medicine not less than four full school years of at least nine months each, including not less than four satisfactory courses of at least six months each in four different calendar years in a medical college, resulting in a degree of M. B. or M. D.; or a diploma or license entitling him to practice in some foreign country. The candidate is then examined in anatomy, physiology, hygiene, chemistry, surgery, obstetrics, pathology and diagnosis, and therapeutics, including practice and *materia medica.* The fee for examination is $25. The regulation of admission to practice is under the control of the Regents of the University, who appoint three State Examining Boards from lists furnished by the three State medical societies, who conduct the examinations; but the Regents issue the licenses. In Illinois, the whole matter is in the hands of the State Board of Health. The requirements are somewhat similar to those of New York, including the four years of medical study and the examination. The penalty for practicing without license is $100 for the first offence and $200 for each subsequent offence.

In Dentistry, license to practice is required in nearly all the States, such licenses being generally issued to those having diplomas from dental colleges, though twenty-three States require a special examination, even where the applicant is in possession of a diploma.

Teachers in the public schools must be licensed in all the States, and a distinctive feature of teachers' licenses is their classification with reference to the proficiency and experience of the applicant, so that the grade of license held by a teacher indicates to the public the relative ability and standing of its possessor.

In Architecture, efforts have been made in a number of States to secure legislation defining the duties and regulating the practice of architecture, but, up to the present time, only three States—California, New Jersey and Illinois—have laws licensing architects. The Committee is informed that there is much difference of opinion among

architects as to the desirability of such laws, and in a number of States where the matter has been agitated the profession has been found almost equally divided for and against them. The Illinois law went into effect July 1st, 1897. It is of unusual interest, as Architecture is a branch of Engineering, and the law and the examinations for which it provides are framed along lines more or less applicable to other branches of Engineering. The law has been in operation long enough to give some idea of its practical working. It may, therefore, be of interest to give an outline of its provisions and the results so far attained. The chief provisions are the following:

Every practicing Architect must be licensed. Any person practicing Architecture as a profession on July 1st, 1897, was, upon proof of that fact, entitled to a license without an examination of his qualifications. Other candidates for license must successfully pass a very full examination, which occupies three days, two of which are devoted to written examinations and one to planning and drawing. This examination has special reference to the construction of buildings, the strength of materials, the details of construction, the supervision of work in progress, and the application of sanitary science in building.

The practicing Architect must impress all plans, specifications, etc., issued from his office, with a seal bearing his name and address. Contractors may prepare their own working drawings, for work they have contracted to do, without violating the law.

The law defines "architect" and "building" as follows:

"Any person who shall be engaged in the planning or supervision of the erection, enlargement or alteration of buildings for others, and to be constructed by other persons than himself, shall be regarded as an architect, within the provisions of this act, and shall be held to comply with the same; but nothing contained in this act shall prevent the draughtsmen, students, clerks of works or superintendents, and other employees of those lawfully practicing as architects, under license as herein provided for, from acting under the instruction, control or supervision of their employers; or shall prevent the employment of superintendents of buildings, paid by the owners, from acting, if under the control and direction of a licensed architect who has prepared the drawings and specifications for the building. The term building in this act shall be understood to be a structure, consisting of foundation, walls and roofs, with or without the other parts; but nothing contained in this act shall be construed to prevent any person, mechanic or builder from making plans and specifications for, or supervising the erection, enlargement or alteration of any building that is to be constructed by himself or employees; nor shall a civil engineer be considered as an architect unless he plans, designs or supervises the erection of buildings, in which case he shall be subject to all the provisions of this act, and be considered as an architect"

The examination fee is $15, and the license fee is $25. The license must be renewed annually, for which the fee is $5. Penalties of $50 to $500 are provided for practicing without a license.

Regarding the practical results from the operation of this law, Dr. N. Clifford Ricker, Professor of Architecture in the University of

Report of Committee on Regulating Practice of Engineering (continued).

Illinois, and President of the State Board of Examiners of Architects, says:

"The general results of the law have been decidedly advantageous to the public, as well as to the profession. Numerous shysters and incompetents have been driven out of practice, especially in Chicago and its vicinity, where a considerable number of men have been prosecuted and fined. The professional status of the Architect has been very materially elevated, and the general public is learning that there is a difference between the Architect and the contractor, and to beware of a person attempting to perform both services at the same time. No man should have an interest in the profits of the erection of a building built under his direction and subject to his approval, acting as the expert advisor and agent of the owner. Draughtsmen in the larger offices have been restrained from practicing on their own account, unless they pass examinations and obtain a license. The professional education and training necessary to the successful practice of Architecture has very materially increased during the existence of the law. Nearly one-sixth of the number of architects licensed without examination have been replaced by men who have passed the examinations now required. At this rate, it may reasonably be expected that incompetent men among those licensed without examination will have left the profession at the end of the next ten years, when all practicing architects will have either passed the examination or possess equal preparation for the work. The professional standing for the architect should then in Illinois equal that of the lawyer or the physician."

In many of the "Trades," or guilds, of this country the conditions under which persons may assume to practice the art or skill of the trade have been quite effectively defined and regulated, but the Committee cannot take up this branch without encroaching too greatly upon the time of the Convention.

The arguments in favor of some effective measure to prevent the practice of quackery in the profession and to protect the public from imposition are so familiar to all that it is unnecessary to repeat and review them in this report. There can be no doubt that a large number among the reputable engineers now in practice are earnestly in favor of regulation and restriction, not only in the interest of the profession, but for the protection and benefit of the public. On the other hand, the discussion of the subject at the last Convention, and since, discloses clearly the fact that a large number of engineers, among them some of the leading members of the profession, believe that such restrictive measures are not only unnecessary, but inexpedient and unwise.

The members of the Committee are not unanimous in the opinion that it is desirable to restrict engineering practice in order to exclude incompetents, even if it were possible to secure satisfactory legislation to accomplish that purpose.

After a careful study of the matter in all its bearings the Committee has arrived at the conclusion that it is inexpedient for the Society to take any action in the matter, at this time, only one of its members inclining to the opposite view.

Some of the reasons that have led to this conclusion are the following:

Legislation intended to regulate and control professional practice should be of substantially uniform character and application throughout the whole of the United States. As it is not within the province of the National Government to enact such legislation, it could only be secured through the independent action of the several States. Experience in attempting to obtain uniform legislation relating to matters of great importance to society has demonstrated that it is very difficult, if not practically impossible, to secure the enactment of uniform laws in even a considerable number of separate States, though the measures proposed may meet the approval of the public, or may at least be not seriously opposed by any considerable number.

It is quite improbable that the legislation necessary to regulate engineering practice could be secured in the several States without the approval and active co-operation of a large majority of the people, and the Committee does not believe that it would be possible to arouse such a degree of public interest in the proposed legislation as to make its enactment possible.

The two main arguments that have been advanced in favor of a measure of this character are that it would be beneficial to the profession, and that it is necessary for the protection of the public. The fact that legislation is designed for the protection of any one class, however large and important that class may be, would very certainly arouse opposition to it, on general principles, and this opposition would be emphasized by the hostility of those whose personal interests might be affected thereby. It might be difficult to convince that part of the public who regard with suspicion any attempt to restrict personal liberty that the members of the profession, in urging such a measure, are actuated alone by a disinterested desire to elevate the profession and to protect the public, rather than by less worthy motives. To whatever extent individual employers may be imposed upon by engineering quackery, the results do not usually affect the community as a whole, and the public, therefore, does not take an active interest in the matter. In this respect engineering is different from the other professions in which legal regulation has been so generally adopted. Thus, the basis on which restrictive legislation has been secured in the practice of Medicine, Pharmacy and Dentistry is the police power of the State to protect life and health; the attorney is, in theory at least, an officer of the Court, and is, therefore, a part of the machinery for the administration of justice; and the character and ability of the public school teacher is a matter in which every citizen is interested and into which he has a right to inquire. No such broad and general basis can be claimed for the engineering profession, except, perhaps, in the case of engineers in official public service, and

Report of Committee on Regulating Practice of Engineering (continued).

with regard to these it is doubtful whether restrictive legislation can be made to apply to elective officials, and there is reason to hope that the improvement and extension of the Civil Service system will effectually exclude incompetent appointees.

To secure the enactment of any laws of the character contemplated it would undoubtedly be essential that the profession shall be united in its demand for them. It is evident that at present such unanimity does not exist.

Granting that restrictive legislation could be secured, and enforced, a careful study of the details necessary to be considered in framing the terms of the measure discloses the fact that very serious difficulties would be met with in attempting to provide, on the one hand, such definite conditions as would make the enactment effective, but which would not, on the other hand, impose restrictions on the individual liberty of the citizen. In some respects the profession is anomalous. No precise and adequate definition of Civil Engineering has been proposed and accepted by either the profession or the public. The wide range and diverse nature of the work of the Engineer makes it very difficult to frame such a definition, and it is not easy to differentiate professional work from that which is not professional, or to distinguish between the function of the professional engineer and that of the skilled mechanic. Furthermore, the profession of Engineering is divided into a number of more or less distinct branches, each with its special line of practice, and each having a separate professional organization; but these branches are so intimately connected with each other, or they so overlap each other in practice, that it would be very difficult to define clearly the line of demarcation between them, and to frame laws which would apply to one without affecting the others. For this reason, if for no other, it would be very desirable that any legislative regulation should be of such a general character as to embrace the whole field of engineering. Such general legislation could not be framed without a very careful study of existing conditions, and of controlling facts and principles from the standpoint of each department of the general profession, and its passage could not be secured without the active co-operation of the professional organizations of the several divisions of the profession. With the exception of the Architects, the other branches of the profession, so far, have shown no active disposition to take up the matter of legislative control of professional practice, and the Committee is of the opinion that efforts to obtain their co-operation at the present time would be fruitless.

The application of the Civil Service examinations to candidates for professional positions in National, State and Municipal service, will, in time, render the existence of special restrictive legislation less important in these departments of professional work. Much remains

to be done before these examinations shall be entirely effective in sifting out a class of incompetents who have heretofore been able to obtain, through political or other influence, positions for which they were unfitted. The testimony of those whose experience makes their opinion of value indicates what while the machinery of the system, as applied to the technical classes, is as yet more or less crude, quite satisfactory results are being obtained, and the hope is justified that as the service is extended and perfected it may render other measures unnecessary wherever it is applicable.

The Committee therefore recommends that no further action be taken in the matter by the Society at the present time.

Respectfully submitted,

S. WHINERY,
DESMOND FITZGERALD,
J. F. WALLACE,
A. N. TALBOT,
EMIL KUICHLING.

THE PRESIDENT.—Gentlemen, what is your pleasure in regard to this report?

A MEMBER.—I move that it be accepted and adopted.

The motion, being duly seconded, was carried unanimously.

THE PRESIDENT.—The next order of business is the report of the Committee appointed at the Annual Meeting of January, 1902, to report on the method of classifying applicants for membership and of raising the qualifications for the various grades.

Report of Committee on Classification and Qualifications for Membership.

H. G. Prout, M. Am. Soc. C. E., read the report, as follows:

REPORT OF A COMMITTEE ON CLASSIFICATION OF APPLICANTS FOR MEMBERSHIP AND ON RAISING THE STANDARD OF QUALIFICATIONS FOR MEMBERSHIP.

At the Annual Meeting of the American Society of Civil Engineers, held January 15th and 16th, 1902, the following resolutions were adopted:

(1) "*Resolved*, that it is the sense of this meeting that the Board of Direction shall have power to classify applicants before their names appear on any published list of candidates; and further

"*Resolved*, that a Committee be appointed to report an amendment to the Constitution which shall embody this idea, at the next Annual Convention for consideration.

(2) "*Resolved*, that a Committee be appointed to report to the next Annual Convention upon raising the standard of qualifications for the several grades of membership."

The President of the Society appointed the undersigned as a committee to report, under the provisions of these resolutions, at the

Report of Committee on Classification and Qualifications for Membership (continued).

Annual Convention to be held May 20th, and that Committee has the honor to report as follows:

(1) Under the present procedure the applicant for membership designates in his application the grade of membership into which he wishes to be elected. It is not material to consider now whether or not the Constitution requires such designation. The practice is established. His name goes out to the Society on the "blue list" as a candidate for membership in such grade. This also is established practice, although apparently not necessary under the Constitution. Not less than 20 days after the issue of the "blue list" the Board considers each application, and may, at its discretion, request the candidate to consent to re-classification; and finally may direct that the name go to ballot.

(2) A committee which reported at the last Annual Meeting found that in the last ten years 32 candidates, who had been rejected by the Society on the secret ballot, have asked for reconsideration, and have been voted upon by the signed ballot known as "the pink ballot." Of these 32, 19 were elected and 13 were defeated. These occurrences have caused some dissatisfaction with the present procedure, and the committee which reported at the Annual Meeting thought it probable that if the candidates were classified by the Board of Direction, the number of rejections would be greatly diminished.

(3) Those who have served on the Board are well aware that it is often expedient and desirable to ask a candidate to submit to a lower classification, and sometimes to accept a higher classification. But it is believed that many men would be reluctant to accept a classification lower than the one in which they have been rated in their first public appearance as candidates, namely, in the "blue list." It seems wise and politic that no public rating of candidates should be made until the Board has decided on the application of each candidate. But this decision cannot be made until that information has been gathered, to collect which the "blue list" is issued.

The Board has ample power now to classify candidates, as it may, at its own discretion, decline to pass a candidate to ballot in any one grade; but the Constitution has been construed to provide that the applicant shall himself designate the class to which he wishes to be elected or transferred, and the official forms of application have been made in accordance with this reading of the Constitution.

Furthermore, the practice has been established of printing the name of the candidate on the "blue list" under the grade which he has himself selected.

(4) As we read the Constitution, all that is asked for in the first of the resolutions under which we were appointed may be accomplished under the Constitution as it now stands, namely: (*a*) The Board may classify candidates at any stage of proceeding, and, in fact, does

classify them sooner or later. (*b*) The Board has now ample power to direct that the "blue list" shall be issued as an unclassified list of candidates. This is a matter of procedure to be governed by considerations of expediency.

(5) But it is desirable and important that the applicants should know from the outset that the Board must eventually designate the class under which any candidate goes to ballot; and that the Board should always have clearly in mind its power and duty in this respect. Further:

It is necessary that the Board should collect information before classifying the candidate, and the most economical and efficient way to collect that information appears to be to send out the name of the candidate on a preliminary list, the present "blue list." But it is important and desirable that in this preliminary list the candidate should appear merely as a candidate for election into the Society, or for transfer, with no indication of the grade to which he aspires.

In Sections 3 and 4 of this Report we have expressed the opinion that the Board has now, (1st) ample power to classify candidates; and, (2d) power to issue the "blue list" as an unclassified list. Yet, we are informed that the Board has interpreted the Constitution as restricting its power in the second particular.

(6) Therefore, in order to remove the idea that the "blue list" must be classified, at least so far as concerns the two grades of corporate membership, we recommend the following amendments to the Constitution:

Amend Art. III of the Constitution, as follows:

Section 2, first line, after the words "Society as," strike out the words "Member or as Associate" and insert the words "a Corporate"; second line, after the word "to" strike out the words "either grade of." Section 2, Art. III, will then read, "An application for admission to the Society as a Corporate Member, or for transfer from any other grade to Corporate Membership shall embody," the rest of the section standing as now.

Section 3, third line, after the word "membership" strike out the words "in any grade," and after the word "transfer" strike out the words "from one grade to another"; twelfth line, for the word "may" substitute the word "shall." The Section will then read as follows:

"At stated periods, to be determined by the Board of Direction, there shall be issued, to each member in any grade, whose address is known, a list of all new applications received for membership or for transfer, which list shall be dated and shall contain a concise statement of the record of each applicant and the names of the references in the case of Corporate Member, and endorsers in the case of Associate, Junior or Fellow, with a request that members transmit to the

Report of Committee on Classification and Qualifications for Membership (continued).

Board any information in their possession which may affect the disposition of the applications. Not less than twenty days after the issue of such list, the Board of Direction shall consider these applications, together with any information in regard to the applicants that may have been received; may make further inquiries, if deemed expedient; shall classify the applicant with his consent, and on applications for Corporate Membership may direct a ballot."

(7) While this report is desired especially to make clear the power and responsibility of the Board in the matters covered, we suggest further that much weight should be given by the Board to the information and opinion of those who write concerning the qualifications of the applicants. In the nature of things, the condensed and meager record of experience can give but an imperfect measure of a man's character and ability; and it may easily be misleading.

The second resolution under which we are appointed directs us to report upon "raising the standard of qualifications for the several grades of membership." The qualifications described in Art. II seem to be all that is judicious and expedient to set forth in the letter of the law. Their severity must remain largely a matter of interpretation by the Board of Direction. A Member must be 30 years old; in the Institution of Civil Engineers (British) he must be 25. He must have had 10 years of practice; in the Institution he must have had five years. In the Society he must have had responsible charge of work for five years and must be qualified to design; in the Institution he shall be actually engaged in a responsible situation. In the grade of Associate Member the Society requires 25 years of age, six years of practice, and one year of responsible charge; the Institution requires that the candidate shall be 25 years of age and shall be actually engaged in design or construction. It is quite apparent that the specified qualifications are higher in the Society than in the Institution. It is also apparent that the phrases "responsible charge" and "qualified to design as well as direct" are capable of a broad range of interpretation, but that they could not be accurately defined in the Constitution. Further, the most important qualifications for membership are not matters of education or ability, but of character; and character could be specified in a written constitution only in general terms. It follows that, in the end, the standard of qualifications for membership must rest mainly in the judgment of the Board of Direction.

It has been suggested that hereafter no new member be elected directly to the grade of Member; but that every Member be required to pass first through a lower grade. It does not seem expedient to put such a restriction on the power of the Board of Direction. If the Board is charged with the specific duty of classifying candidates before they are passed to ballot we may well rest there, for, as has been pointed

out above, the standard of qualifications comes back finally to the judgment of the Board.

We recommend no change in the qualifications for either grade as now prescribed in the Constitution.

All of which is respectfully submitted,

H. G. Prout, *Chairman.*
H. A. Carson,
T. H. Johnson,
E. J. Blake,
D. Bontecou,
Jas. D. Schuyler.

I subscribe to the above report except the last paragraph which I would make to read as follows:

"We recommend no change in the qualifications for either grade *of corporate membership* as now prescribed in the Constitution."

G. S. Williams.

The President.—What is your pleasure, gentlemen, with regard to this report? If there be no objection, it will be received and filed, and the question of its adoption will be left open. Is there any motion? Discussion on Report of Committee.

A Member.—Will it be necessary to amend the Constitution as proposed?

The President.—The reception of the report simply files it. If it is a question of the matter of the report, it should come up on a distinct motion, either to adopt the amendments of the Committee or to adopt other amendments.

A Member.—I move that the report be received and filed.

The motion was duly seconded.

A Member.—I would like to ask whether there is any motion necessary to secure the adoption of the amendments?

The President.—I suppose amendments to the Constitution would have to pass the regular routine.

The Secretary.—The Constitution provides that an amendment proposed by a certain number of members, I think five, shall be presented to the next general meeting of the Society for discussion. If that general meeting does not amend the proposed amendment, it must be voted upon by the Society at large. As I understand it, this is a report to the Society by a Committee, but, as individual members of the Society, no amendment has been proposed. It would therefore be necessary, in order to comply with the Constitution, that the members of the Committee, or some other members of the Society, should present the matter of this proposed amendment to the Constitution in the regular form, although the Committee could do that as well as anybody else.

The President.—I think the interpretation of the Constitution by the Secretary is correct. Are there any remarks upon this motion,

Discussion on Report of Committee (Continued).

which is to receive and file this report? If not, those who are in favor of receiving and filing this report will signify by saying "aye."

The vote being taken, the President announced the motion carried.

WILLIAM P. CRAIGHILL, Past-President, Am. Soc. C. E.—If it be in order, I would like, at this stage of the proceedings, to offer a resolution looking to the amendment of the Constitution, following to some extent the line of the report of this Committee. If the Secretary will be kind enough to read it, and if it be in order, I will offer that resolution.

The Secretary then read the resolution, as follows:

Proposed Amendment to the Constitution.

"*Resolved*, That the Board of Direction be requested to frame an amendment to the Constitution which shall do away with the secret letter-ballot now used in the election of corporate members, and substitute therefor an open or signed ballot."

The motion was seconded by A. P. Boller, M. Am. Soc. C. E.

MR. CRAIGHILL.—I do not wish to detain the Society at this moment in a discussion of the resolution which is before the Society, but I want, however, to say this: Of course, I wouldn't have offered the resolution if I didn't approve it, and my approval is based upon experience, which is an excellent teacher, and that experience is one I had as a member of the Board of Direction for eight years. Of course I would be very glad to hear the resolution discussed, and after that would have something to say on the subject.

THE PRESIDENT.—The Chair would call attention to the first section of the article on amendments, which says:

"Proposed amendments to this Constitution must be reduced to writing and signed by not less than five Corporate Members, and be submitted and acted upon as follows."

Now, the point is whether the Board of Direction can submit an amendment except as individuals, and it seems to me that is the correct interpretation of the Constitution, that they cannot, in their official capacity, submit amendments; but that must be done by individuals, as indicated in this article.

THE SECRETARY.—I call attention to the fact that this resolution requests the Board of Direction to frame an amendment only, and necessarily it would have to come before the Society at another meeting. I don't know whether that would make any difference in your ruling or not.

MR. CRAIGHILL.—If you rule that the resolution is not in proper shape, I will withdraw it and put it in proper shape.

THE PRESIDENT.—As the Chair understands the resolution, it means that the Board should present the amendments. If it is only to frame them, I presume there is no objection to it.

MR. CRAIGHILL.—The reason the resolution is drawn in this shape is this: It is a subject that comes before the Board of Direction, and they are very familiar with the subject, more so than any other members of the

Society, and it seemed to me not improper that they should be called upon to put the amendment in proper shape for submission to the Society. The members of the Board of Direction are members of the Society, and, as I understand, the Constitution permits any members of the Society, whether they belong to the Board of Direction or otherwise, to submit amendments that may be incorporated in the Constitution in the proper way, so that the Constitution does not seem to me to disqualify the Board of Direction as members of the Society from taking any action that any other members of the Society might take.

J. JAMES R. CROES, Past-President, Am. Soc. C. E.—It seems to me it would give us a precedent in the presentation of such an amendment which would be misunderstood by a great many members. It would be equivalent to a recommendation by the Board of Direction that the Constitution be amended as proposed.

It appears like an effort to give an official sanction to the ideas of a few members preliminary to their being presented to the whole Society, which is not in accordance with the spirit of the Society or of the Constitution. If the gentlemen who desire this amendment will present it in proper shape, the matter can be brought before the Society as the action of individuals desiring the amendment, and not as the official action of the Board of Direction asking for an amendment to the Constitution, which they may or may not approve of. This would require them to present an amendment of which they might not approve, but they have got to present that amendment under that resolution. It isn't their business to do it, and it isn't proper it should be done that way.

H. B. SEAMAN, M. Am. Soc. C. E.—I was simply going to make some remarks in the general direction to which Mr. Croes' remarks tend, that this motion instructs the Board; it does not leave them any discretion as to the purpose of the motion to have signed ballots. I have not thought as much of it as some others and the gentleman himself, but it does not strike me favorably, for this reason, that the Board finds to-day the greatest difficulty in obtaining evidence against applicants although correspondence is supposed to be in every case confidential. People will not sign letters and send them in, even confidentially, to the Board. If such is the case, I think it will be much more difficult to persuade members to sign against applicants in an open ballot, and in that way we throw open the doors and will probably let in a great many objectionable candidates. It has been proposed that the election shall be placed entirely in the hands of the Board. Nobody knows the difficulty of such a proposition better than the members who have acted on the Board. It is a very difficult proposition, the proper election of our membership to-day, and the present agitation arises from the fact that almost anyone can get in through

Discussion on Proposed Amendment (continued).

the pink ballot. I think it would be much easier for them to get in through the proposed amendment. There is another objection to the present system, which is that there is a great deal of blackballing; one member will blackball a whole list. I think the objections to the present system, although they are serious objections, are less than those to the system proposed.

Mr. Craighill.—Would it be proper for me to offer a resolution requesting the President of the Society to appoint a Committee of members present to put this thing in proper shape? I want to see it go through, and I want to get it before the Society in a proper way. Would it be proper for me to move for the President to appoint a Committee of the members present, or any others he may think proper?

The President.—I see no legal objection to that, although it is a question whether he could do it better than the members who would offer such an action; but that wouldn't go to the legality of it.

Mr. Croes.—That would be open to the same objection which is made to this present amendment to the Constitution, which is presented by the Committee under the instruction of the Annual Meeting. It has been ruled that that report of the Committee reporting an amendment is not——

Mr. Craighill.—May I interrupt for one moment?

The President.—With Mr. Croes' permission.

Mr. Craighill.—I withdraw the resolution.

Mr. Croes.—I have nothing more to say then regarding that resolution, but I would like to call attention to the fact, if it is not too late to reverse the ruling of the Chair on that matter, that this Committee was appointed to make a report on the method of classifying applicants for membership, and they have made that report, and the ruling is made that it is not the offering of an amendment.

The President.—I think that is correct. That amendment may be offered by five individuals.

Mr. Prout.—When a Committee is appointed to report an amendment, isn't the presentation of that report the offering of the amendment by the individuals composing that Committee?

The President.—If they so offer it as individuals.

Mr. Prout.—Mr. President, the second resolution reads that a Committee be appointed to report an amendment to the Constitution. Now, our Committee considers that we have complied with our instructions to report an amendment to the Constitution. Whether we must now resolve ourselves into seven individuals and put in the amendment in another form is rather a nice question.

Mr. Croes.—Does an amendment to the Constitution have to be offered at a regular meeting?

The President.—No, sir.

MR. CROES.—Can the Committee or anybody else put their names to that and offer it?

THE PRESIDENT.—The article on amendments, Sections 1 and 2, reads:

"Proposed amendments to this Constitution must be reduced to writing and signed by not less than five Corporate Members, and be submitted and acted upon as follows:

"Amendments presented to the Secretary on or before the first Wednesday in November shall be sent by letter to the several Corporate Members of the Society at least twenty-five days previous to the Annual Meeting. Such amendments shall be in order for discussion at such Annual Meeting, and may be amended in any manner pertinent to the original amendments by a majority vote of the Annual Meeting, and if so amended, shall be voted upon by letter-ballot in form as amended by the Annual Meeting; if not so amended, they shall be voted upon by letter-ballot as submitted. * * *"

I will not read the rest of it, but it seems to me this is exclusive of any other method of submitting amendments.

MR. PROUT.—Mr. President, the fourth section of this article says that if after discussion of a proposed amendment, at either of the general meetings of the Society, the meeting shall so decide by a majority vote, it may refer the amendment to a committee for further consideration, which committee shall report at the next general meeting.

Now it seems to me that that is precisely the procedure that has been taken, up to this stage. This was discussed at the last meeting. That meeting decided by a majority vote to refer it to a committee. It was referred to the Committee. Now, "which committee shall report at the next general meeting," which we have done this morning. "Whereupon the amendment shall be voted upon as hereinbefore provided." Now, we have got to that stage, it seems to me, to the stage hereinbefore provided, whatever that may be.

A MEMBER.—I would like to ask the speaker when it was that the amendment took the first step.

MR. PROUT.—Last January, at the Annual Meeting.

A MEMBER.—I was present at the meeting, but do not recollect it.

MR. PROUT.—Well, whenever the discussion came up.

A MEMBER.—Mr. Secretary, when was the amendment now presented as a report passed through its first stage and presented to the Society?

THE SECRETARY.—It has never gone through any stage.

HENRY S. HAINES, M. Am. Soc. C. E.—Mr. President, pardon me for intruding into this discussion, but I would like to ask the President what the question is.

THE PRESIDENT.—The question, as I understand it, is whether the recommendations of this Committee constitute a proposed amendment within the meaning of the Constitution.

Discussion on Proposed Amendment (continued).

MR. HAINES.—I thought the report of the Committee had been disposed of, and another matter was brought up, and that resolution was withdrawn. It is an entirely different matter.

THE PRESIDENT.—The report was received and filed, but that left open any further action upon the same subject, and Mr. Prout raises the question as to whether this is a proposed amendment, if proposed in the form already indicated by the Constitution.

THE SECRETARY.—Mr. President, there was an amendment to the Constitution proposed in due form last fall, and it came before the Annual Meeting, in January, and the action of that meeting—rather, not the action of that meeting, but the action under the Constitution, required that the amendment should go to ballot unless amended by the Annual Meeting. The Annual Meeting did not amend that amendment, and it went to ballot and was defeated. At that meeting this matter came up anew, and a Committee was formed and instructed to report on this matter. It was not an amendment which had been duly presented to the Society.

THE PRESIDENT.—In view of that state of facts the Chair thinks that this needs to be proposed as an original measure.

J. M. KNAP, M. Am. Soc. C. E.—Mr. President, I would suggest that Col. Prout, the Chairman of that Committee, secure four other good men to sign a well-worded amendment, and have it presented to this meeting. It seems to me that would simplify the matter, and then it can be put out as a proposed amendment. It has nothing to do with the reception of his report.

THE PRESIDENT.—Of course not. The report is received; and of course that amendment need not be made to this meeting. It cannot be acted upon as an amendment to the Constitution at this meeting, although discussion of the general subject is open.

MR. CROES.—It does seem that whether further consideration involves an amendment or not, the matter is referred to the Committee for further consideration, on which the Committee shall report at the next general meeting, whereupon the amendment shall be voted upon as hereinbefore provided.

THE PRESIDENT.—The question of fact, stated by the Secretary, without contradiction, as far as I know, is that an amendment on this general subject has been submitted to ballot and defeated, that another amendment upon the same general subject is proposed as suggested by this Committee, and that it does not become a proposed amendment within the meaning of the Constitution unless signed by five members and submitted in that form.

A MEMBER.—I move that this Committee be continued, to present the proposed amendment to the Constitution in due legal form to the Society.

The motion was duly seconded.

A MEMBER.—Is that motion constitutional?

THE PRESIDENT.—The Chair sees no reason to rule otherwise.

CLEMENS HERSCHEL, M. Am. Soc. C. E.—I should judge, from being an attentive listener, that that motion is unconstitutional. It is not the way to present the proposition. My sympathies are with the speaker who suggested to the Chair that there is no question before the meeting. Now, there is or is not a question before the meeting. If there is, I should like to have it put; if not, I should like to pass to something new.

THE PRESIDENT.—The motion last made, I think, is a proper one. I think this Committee can take steps to have it properly presented to the Society, and that motion is now before the house.

A MEMBER.—If it is in order to make a remark on that question, I think it is an unnecessary step. The Constitution has provided the means by which any set of five members can bring their wishes before the Society and have them acted upon by the whole Society. It does not seem competent for a convention meeting to take the initiative and instruct the Committee to do something. The meeting is not properly a body which can present the amendments. I think it is a waste of time to do this. It has got to be done and signed by five individuals, and it does not require this action.

MR. HERBERT M. WILSON.—Mr. President, is there a motion before the house?

THE PRESIDENT.—There is a motion before the house, which the stenographer will read.

MR. WILSON.—I should like to offer an amendment to it. I should like to amend that motion to read that this Society accept the amendment to the Constitution presented in writing and signed by this Committee as a formal amendment to the Constitution to go through its usual course.

MR. HERSCHEL.—I hope that the amendment and the motion to which it applies, both, will not prevail. It is the same thing Mr. Croes has spoken about, only in another form. It is giving an official sanction, and the sanction of the Society, as it were, to a petition that is going to be signed by five members. Now, why can't these five members act without this spur from the meeting? The Constitution says it must be done in that way, and, if it must be done in that way, it should not and probably cannot be done in any other way.

It was duly moved, seconded and carried that the matter be laid upon the table.

Report on Time and Place for next Convention.

THE PRESIDENT.—The report of the time and place for holding the next Convention is the next order of business.

THE SECRETARY.—Mr. President, in answer to the usual circular which has been sent out, the members of the Society have replied as follows:

Report on Time and Place for next Convention (continued).

" NEW YORK, May 19th, 1902.

" TO THE AMERICAN SOCIETY OF CIVIL ENGINEERS:

" I beg to report the result of the ballot on Time and Place for Holding the Annual Convention of 1903, as follows :

" Total number of votes received for Place (to May 19th, 1902), 306.

" Distributed as follows:

St. Louis, Mo	68	Havana, Cuba	5
Cleveland, Ohio	35	Birmingham, Ala	5
Pittsburg, Pa	28	Asheville, N. C.	4
City of Mexico	26	Mackinaw Island	4
Chicago, Ill	23	Seattle, Wash	3
Boston, Mass	19	Philadelphia, Pa	3
New Orleans, La	14	Old Point Comfort, Va	3
New York City	9	Sault Ste. Marie, Mich	3
Denver, Colo	6	San Francisco, Cal	3

Some point on the Great Lakes...... 3

" The following places received 2 votes each:

Atlantic City, N. J. — Saratoga, N. Y.
Montreal, Canada. — Cincinnati, Ohio.
Minneapolis, Minn. — Niagara Falls, N. Y.
Atlanta, Ga.

" The following places received 1 vote each:

Albany, N. Y.	Dallas, Tex.
Lake Champlain, N. Y.	Coney Island, N. Y.
Lakewood, N. J.	Milwaukee, Wis.
Bar Harbor, Me.	Quebec, Canada.
Nantasket Beach, Mass.	White Sulphur Springs, Va.
Kansas City, Mo.	Halifax, Nova Scotia.
Alexandria Bay, N. Y.	Lake George, N. Y.
Richmond, Va.	Buffalo, N. Y.
Yellowstone National Park, Wyo.	Eureka Springs, Ark.
Tampa, Fla.	Charleston, S. C.
Norfolk, Va.	San Juan, Porto Rico.
Sydney, Cape Breton, Nova Scotia.	Thousand Islands, N. Y.
Duluth, Minn.	Katerskill, N. Y.
Hancock, Mich.	Some Canadian point.

" Total number of ballots received on Time for next Convention, 270.

	No. of votes.		No. of votes.
February	4	November	2
March	6	December	2
April	11	Autumn	1
May	87	Midsummer	1
June	107	Summer	1
July	16	Winter	1
August	7	Early Spring	1
September	10	Late Fall	1
October	5	During Exposition at St. Louis	7

" Since the foregoing list was compiled, more than 300 postal cards in favor of Cleveland, Ohio, have been received.

" Respectfully submitted.

" CHAS. WARREN HUNT,

" *Secretary.*"

Mr. President, this report was written before leaving New York. On the arrival of the special train at Washington, the Secretary received a stack of postal cards, all of which were votes for holding the convention in Cleveland. Some of them were reconsiderations of votes already received and referred to in this report. It has been impossible to classify those so as to give an accurate statement of the ballots as received, but there have been more than 300 votes, received since the Society has been in convention in Washington, in favor of holding the next convention in Cleveland. (Applause.)

A. MORDECAI, M. Am. Soc. C. E.—I think the Secretary has some invitations from Cleveland as to the convention which I should like to have read.

Letters Regarding Time and Place for next Convention.

THE SECRETARY.—Also from other places.

MR. MORDECAI.—Only from Cleveland. I don't care anything about the other places.

THE PRESIDENT.—The Secretary will read them.

The Secretary read the following letters from Cleveland:

"CLEVELAND, OHIO, May 15th, 1902.

"*The American Society of Civil Engineers*,
"Willard Hotel,
"Washington, D. C.

"GENTLEMEN,—As Mayor of the City of Cleveland, I cordially invite your Association to hold its next convention in Cleveland. I am sure Cleveland will be proud of the honor and will put forth every effort to make your visit a pleasant one.

"Yours very truly,

"TOM L. JOHNSON,
"*Mayor*."

"MR. CHARLES WARREN HUNT,
"*Secretary*,
"Washington, D. C."

"CLEVELAND, OHIO, May 19th, 1902.

"MR. CHARLES WARREN HUNT,
"*Secretary, American Society of Civil Engineers*,
"Washington, D. C.

"DEAR SIR,—On behalf of the business men of Cleveland, the Board of Directors of the Cleveland Chamber of Commerce extends to your Society a very cordial invitation to hold its summer meeting of 1903 in Cleveland. The directors are confident that your delegates would thoroughly enjoy the time spent in Cleveland, and it is sincerely hoped that the city may be honored by an acceptance of this invitation.

"By order of the Board of Directors of the Cleveland Chamber of Commerce.

"F. A. SCOTT,
"*Secretary*."

"CLEVELAND, OHIO, 19th May, 1902.

"MR. CHARLES WARREN HUNT, *Secretary*,
"*and Members of the Am. Soc. C. E.*

"GENTLEMEN,—It is with great pleasure that we hand you herewith the invitation of the Cleveland Chamber of Commerce for your

Letters Regarding next Convention (continued).

summer meeting of 1903. We trust that Cleveland's invitation will be favorably considered and that we shall again have the pleasure of receiving in the Forest City the delegates of your noted Society, which has not so favored us in twenty-three years.

"Wishing you every success, we remain, respectfully,

"THE EXECUTIVE COMMITTEE OF THE CONVENTION BOARD,

"By ABRAHAM STEARN,

"*Vice-President.*"

J. A. OCKERSON, M. Am. Soc. C. E.—I have presumed that the votes cast for St. Louis were largely on the supposition that the Exposition would be held there in 1903. Matters pending in Congress now look to a postponement until 1904, and at that time we hope to see the Society in St. Louis.

THE SECRETARY.—I also have some letters from another point. Shall I read them?

THE PRESIDENT.—Yes.

The Secretary then read the following letters from Birmingham, Ala.:

"BIRMINGHAM, ALA., June 19th, 1902.

"Mr. C. W. HUNT, *Sec'y*,

"*American Society of Civil Engineers*,

"Willard House, Washington, D. C.

"DEAR SIR,—The Mayor and Aldermen and the Commercial Club of this city have passed resolutions asking that the members of your organization use their influence to have your next annual meeting in 1903 held in Birmingham.

"Owing to the great developments that have been made during the past few years in industrial and engineering matters and the remarkable geological formation of this section, we think that we have many matters that would interest you.

"In extending this invitation to your association, I feel assured in saying that the hotel accommodations will be ample, and that large halls amply sufficient in which to hold your meetings will be furnished.

"As chief executive of this city, I have appointed Col. J. A. Montgomery of this city and other representatives from this district to use their utmost efforts to secure your next convention in 1903.

"Should you accept this invitation to come here, I most heartily assure you that a cordial welcome will be given and old fashioned Southern hospitality extended to you.

"Yours truly,

"W. M. DRENNEN,

"*Mayor.*"

"BIRMINGHAM, ALA., May 17th, 1902.

"*Secretary of American Society of Civil Engineers*,

"Washington, D. C.

"DEAR SIR,—The Commercial Club of Birmingham, Ala., at a meeting held yesterday, passed a resolution most cordially inviting the American Society of Civil Engineers to hold its Convention for the year 1903 in the City of Birmingham.

"Our city and district have made such wonderful progress in the last decade that we feel sure that there are many things here which will interest the members of your body, and we would do everything in our power to make your stay here pleasant and agreeable.

"Very respectfully yours,

"J. B. Gibson,

"*Secretary.*"

"Birmingham, Ala., May 19th, 1902.

"Mr. Charles Warren Hunt,

"*Sec'y, A. S. of C. E.*,

"Washington, D. C.

"Dear Sir,—At a meeting of the B'gham Section of the Engr. Ass'n of the South, the Secty. was directed to extend a cordial invitation to the American S'y of Civil Engrs. to hold their 1903 annual meeting in Birmingham, Ala., and assure you that a hospitable greeting will be tendered and every assistance given by the members of this Ass'n to make your visit an interesting one.

"Col. J. A. Montgomery was appointed to urge the acceptance of this invitation, he being a member I believe of the American S'y.

"Yours very truly,

"Geo. H. Harris,

"*Sect'y.*"

Discussion on Time and Place for next Convention.

The President.—Gentlemen, the subject is open for your action.

Benjamin M. Harrod, Past-President, Am. Soc. C. E.—I move that the whole subject be referred to the Board of Direction.

The motion was duly seconded.

The President.—Are there any remarks?

Jacob L. Ludlow, M. Am. Soc. C. E.—It appears to me that our Board of Direction is very much overworked. They do a great deal of work for the Society, and this is something which the Society can decide for itself here at this meeting and not refer to the Board of Direction. We have invitations, both very cordial ones, from Cleveland and Birmingham. We cannot accept either one of those, for if we accept one the other will certainly feel hurt. It is very much like making a choice between two maidens, and taking one when you want them both. You can't have both. I propose to suggest a place which will relieve the necessity of a choice between those two, one which has not sent a formal invitation, because they were a little modest and hardly would expect to be honored by a visit of this Society to the locality which I shall mention. We were told yesterday by the gentlemen who graciously welcomed the Society that the engineers of America had accomplished about everything there was, real and tangible, in engineering science and skill. They did not tell us, however, of all the beautiful things which the engineer requires to mix up with his real work. There is a point in North Carolina which will inspire the gentlemen, members of this Society, with the broadest idea of the beautiful, the truly lovable, and would we adopt the æsthetic beauties of our profession we must study

Discussion on Time and Place for next Convention (continued).

the beautiful, and the one place east of the Rocky Mountains which the United States Government has been able to find which in any degree would rival the Yellowstone Park is in North Carolina. There all the beauties of Nature are to be seen from the porticos of the Battery Park Hotel. That hotel is just of sufficient size to accommodate the entire party that would attend the convention of the Society. The proprietor at some time in June will, I am sure—in fact, he has told me he would—turn over the entire hotel to this organization, so we can all be there together, ourselves, our wives and our sweethearts, boys and girls all together, where we can have a delightful time. Large halls to hold the business sessions, large dance halls, refreshments, and so forth. They would give us all the entertainment we want. We don't want to accept too much hospitality. As engineers, we are used to being pulled around, and we don't care to be pulled to St. Louis and thence from place to place. It is like a full man, he does not want too much meat, he wants something to drink. In Asheville, we can have the drink. There are mountains all around. There is the most magnificent piece of railroad building east of the Rocky Mountains, which you would enjoy in passing, and when you reach Asheville—I can't describe the beauties of it. But I arose to propose that this committee to-day be relieved of this work, and that just now this meeting select Asheville for the Convention in the month of June. I move, to amend the motion, that Asheville be selected as the place of meeting, in the month of June, 1903. (Applause.)

The motion was duly seconded.

A Member.—I would like to second that motion, particularly as in wandering around through the members who are here now you find so many who are speaking of Cape May. Cape May didn't have any engineering features to show us, but we were all in one hotel together, and there were friendships formed there; and Asheville is a place finely located, a beautiful place, and Mr. Ludlow says it is a delightful place, and the hotel entirely capable of accommodating the Society.

A rising vote being taken on the amendment, the Secretary announced the vote as 59 for and 32 against.

The President.—The amendment is carried. (Applause.)

The President.—The action now comes upon the motion as amended.

A Member.—What is that motion?

The President.—This is an amendment. The original motion becomes now that this Society shall hold its next Convention at Asheville. That is now open for discussion.

Mr. Seaman.—Mr. President, I would like to say I am with the majority in favor of going to Asheville, but I hesitate very much about making a precedent of this kind by which a gifted orator can stampede

the Convention. (Applause.) We know what that is in National politics.

MR. LUDLOW.—I object to any comparison with Mr. Bryan.

MR. SEAMAN.—I believe those remarks were taken down, and I know that they will be considered by the Board. I have every faith in the conservative action of the Board. I am strongly in favor of Asheville, but I hope we will not carry this motion at the present time.

MR. CROES.—I move that the matter be referred to the Board of Direction, with the statement it is the sense of this meeting that the Convention be held at Asheville.

THE PRESIDENT.—Do you move that as an amendment?

MR. CROES.—Yes.

The amendment was duly seconded.

THE PRESIDENT.—The amendment has been proposed, so that the wording be changed, that it is the sense of this meeting that the next Convention be held at Asheville. That is open for discussion.

MR. LUDLOW.—Isn't it the fact that the Board has the authority to fix the time and place, or is it only done through the action of the Convention?

THE SECRETARY.—It is done through the action of the Society.

MR. LUDLOW.—Then I understand the effect of the motion of the gentleman who has just spoken is, that this matter be referred to the Board with the power to fix the time and place, it being the sense of this meeting that the Convention be held in Asheville; is that the proposition?

THE PRESIDENT.—That will be the effect of it; that it be referred, with the statement that it is the sense of this meeting that it be held in Asheville.

MR. HARROD.—The amendment is accepted.

THE PRESIDENT.—The motion then stands that this matter be referred to the Board of Direction, it being the sense of this meeting that the next Convention should be held at Asheville.

GARDNER S. WILLIAMS, M. Am. Soc. C. E.—I rise to a point of order.

THE PRESIDENT.—What is the point?

MR. WILLIAMS.—The point being that the meeting has already amended the original motion, and therefore the original mover has no more control of it, to accept or refuse the amendment. The meeting is the only one to amend that motion.

THE SECRETARY.—I should like to have a definite ruling, for the purpose of our record as to what did happen about this Asheville resolution. The resolution was passed that the next Convention should be held at Asheville, North Carolina.

THE PRESIDENT.—That was an amendment of a pending motion, and that left the original motion to be put, and, pending the consideration of the original motion as amended, Mr. Croes' motion is made that it

Discussion on Time and Place for next Convention (continued).

be referred to the Board of Direction with the statement that it is the sense of this meeting that it be held at Asheville, and that is in the nature of an amendment of the original motion.

WILLIAM WATSON, M. Am. Soc. C. E.—Mr. President, I believe an original motion has been put and two successive amendments have been made. Now, if I make the motion for the previous question, the whole thing will come up on the original motion. I therefore move the previous question.

THE PRESIDENT.—I will direct the gentleman that the original amendment has not been put.

MR. WATSON.—It will cut off the two amendments; the motion I make is, that the previous question be put.

THE PRESIDENT.—The Chair hears no call for the previous question.

MR. G. S. WILLIAMS.—I want to say a word in regard to the amendment now pending before the Society, and in regard to the motion under consideration. It seems to me that while there is no doubt that there is a large sentiment in this room in favor of meeting in Asheville, in which I fully concur, it might not be right to tie up the Board of Direction by the passage of this resolution in the proposed amended form. Something might turn up, before the time comes for setting the Convention, which may lead to a more suitable choice elsewhere. I therefore feel that we might do better to simply refer this whole matter to the Board of Direction without any instructions, they knowing fully the sentiment which has been expressed here, and I, myself, feel that the Board of Direction would take all due cognizance of that sentiment and at the same time would be free to make other arrangements, if, for any reason, it should be desirable.

THE PRESIDENT.—That is a statement of fact.

MR. WILSON.—I want to add merely one more remark in agreement with the last speaker. Personally, I am very much in favor of Asheville. At the same time I do not like to see these precedents overruled, and those of us who were present at the Convention in Niagara will recall that there was a similar discussion as to our coming to Washington, and the matter was withdrawn and was left to go to the Board of Direction without instructions. I think it an admirable plan, and I hope that the members of this Convention in voting may see their way to vote with a view to leaving the whole matter to the Board of Direction without instructions. (Applause.)

MR. LUDLOW.—It appears that the sense of the meeting has been expressed, and Asheville is already selected. Of course, the gentlemen who did not vote for Asheville have in mind some other place, and they would like to leave the situation so that Asheville may be side-tracked. It is a pretty hard proposition, but I myself do not care to see any precedent broken in that way. I think the Board of Direction, if they prefer to perform these functions, should be allowed to do so. I don't

want to run counter to their wishes. If the gentleman who made the last amendment will simply make one change, I think those who didn't vote for Asheville will adopt this proposition, that the matter be referred to the Board of Direction without instructions, that it is the unanimous wish of this meeting assembled. (Laughter and applause.)

THE PRESIDENT.—The motion is upon Mr. Croes' amendment that this matter of the holding of the Annual Convention be referred to the Board of Direction, with the statement that it is the sense of this meeting that it shall be held in Asheville. Those who are in favor of that amendment will signify it by saying "aye."

The "ayes" having voted, the Chair announced the motion carried.

MR. WILSON.—Don't the "noes" get a chance? When the "noes" understand that these are instructions to the Board of Direction they will all vote on it.

THE PRESIDENT.—If the Chair failed to call the "noes" he was in error, and I now call for the "noes" on Mr. Croes' amendment that it be referred to the Board of Direction, with the statement that it is the sense of this meeting that it be held at Asheville. I will have to ask those in favor to stand up and be counted.

MR. WILSON.—I think there are a number who don't understand this.

THE PRESIDENT.—If amended it will stand as amended to be acted on then by the meeting as counted.

A rising vote being taken, it was announced 70 in favor and 14 against.

THE PRESIDENT.—The motion now stands as amended by Mr. Croes' motion, and is before the house.

The motion was put to vote and carried.

Special Committee on Analysis of Iron and Steel, Discharged.

THE SECRETARY.—I am directed by the Board of Direction to report that the Board recommends that the Special Committee on Analysis of Iron and Steel, sub-committee of the American Society of Civil Engineers, of the International Committee on Standards for the Analysis of Iron and Steel, of which Professor J. W. Langley is Chairman, be discharged.

A motion to the above effect, being duly seconded, was carried, and the President declared the Committee discharged.

Special Committee on Units of Measurement Discharged.

THE SECRETARY.—The Board recommends that the Special Committee on Units of Measurements be discharged.

The motion, being duly seconded, was carried, and the President announced the Committee discharged.

MR. WILLIAMS.—I want to call attention to one little omission which it seems to me should be corrected, reviewing the proceeding on this question of referring the matter to the Board of Direction. We have amended the motion, but we have not yet adopted the motion as amended.

THE PRESIDENT.—I think we did do that.

THE SECRETARY.—The railroad representative here who has viséd the certificates tells me that if the members of the Society should go in bunches of ten or fifteen, or even five, to the station to get their tickets on the certificate plan for the return, they probably would lose several trains before they could purchase them, and that therefore it is necessary for them to attend to the purchase of return tickets as early as possible on the day of departure, and that the best places to handle that business are the uptown ticket offices in the neighborhood of the Treasury Department.

A MEMBER.—Must that be on the day of departure?

THE SECRETARY.—Unless you leave early in the morning.

Adjourned.

EXCURSIONS AND ENTERTAINMENTS DURING THE THIRTY-FOURTH ANNUAL CONVENTION.

The arrangements for the Convention were in the hands of the following Committees:

Committee of the Board of Direction.

MORDECAI T. ENDICOTT, *Chairman.*
GEORGE H. PEGRAM, CHAS. WARREN HUNT.

Local Committee.

GEORGE W. MELVILLE, *Chairman.*
JOHN BIDDLE, CONWAY B. HUNT,
WILLIAM M. BLACK, DAVID E. MCCOMB,
DAVID S. CARLL, ALEXANDER MACKENZIE,
BERNARD R. GREEN, ALEXANDER M. MILLER,
HERBERT M. WILSON.

By the courtesy of the Pennsylvania Railroad a special train was made up for members of the Society and their guests, to run from New York to Washington. This train left Jersey City at 1.14 P. M. on Monday, May 19th, made stops at Newark, Trenton, Philadelphia and Baltimore, and arrived in Washington at 6.10 P. M.

The Pennsylvania Railroad made a special rate of a single fare for the trip to Washington and return. By arrangement with the Trunk Line Passenger Association, a rate of one and one-third fare was secured for all who attended the Convention.

In the afternoon of Tuesday, May 20th, through the courtesy of the Washington Railway and Electric Company, a large party of members and guests made an excursion to Cabin John Bridge, the return trip being made by way of Chevy Chase.

The illustrated talks, descriptive of various engineering features in Washington and vicinity, delivered by several of the local members, during the evening of Tuesday, May 20th, formed one of the most interesting and instructive features of the Convention.

On Wednesday, May 21st, at 9.45 A. M., the members of the Society were received at the White House by the President of the United States.

During the afternoon of Wednesday, May 21st, a large party of members and guests visited the Washington Navy Yard, where every opportunity for inspecting the gun factory, towing tank and apparatus for testing ship models was furnished. During the visit a jacket was shrunk on a 12-in. gun.

On Thursday, May 22d, a party of about 600 members and guests visited the Washington Barracks and witnessed an exhibition of pontoon bridge building by the Engineers' School and Battalion.

Immediately thereafter the party boarded the Steamer *Macalester* and sailed down the Potomac to Fort Washington, where the operation of the 10-in. guns on disappearing carriages was described, and a gun fired. Again taking the steamer, the party proceeded to Marshall Hall, where a planked-shad dinner was served.

After dinner, Mt. Vernon was visited. After inspecting the house and grounds, the party listened to an interesting address on George Washington as a Surveyor and Civil Engineer, by Herbert M. Wilson, M. Am. Soc. C. E. The party reached Washington at 5.30 P. M.

In the evening, commencing at 9.30 P. M., an informal dance in the ballroom of the Willard was enjoyed by a large number.

On Friday, May 23d, parties were conducted by the local members to a number of points of engineering and general interest. among them being the Capitol, Library of Congress, Washington Monument, National Museum, Geological Survey, Coast Survey, War Department, National Cemetery, etc.

Upon the invitation of the Trustees of the Corcoran Gallery of Art a reception was held at the Gallery in the evening from 8 to 11.

THE ATTENDANCE AT THE THIRTY-FOURTH ANNUAL CONVENTION.

The following 343 members were in attendance:

Abbott, F. V......Washington, D. C.
Abert, S. T.......Washington, D. C.
Ackermann, E. R.....New York City
Adams, Raymond E., Washington, D. C.
Aiken, W. A...........Pittsburg, Pa.
Allen, C. H.......... New York City
Allen, Henry C.. ....Syracuse, N. Y.
Allen, James P......Charleston, S. C.
Allen, Kenneth.......Baltimore, Md.
Allen, William A.......Maurer, N. J.
Andrews, Horace......Albany, N. Y.
Asserson, P. C.......Brooklyn, N. Y.
Aus, Gunwald...... .New York City
Averill, F. L......Washington, D. C.
Aylett, P............Portsmouth, Va.

Babb, C. C........Washington, D. C.
Bacon, J. W.........Danbury, Conn.
Baldwin, F. H.......Bayonne, N. J.
Barnsley, George T....Oakmont, Pa.
Bassett, G. B..........Buffalo, N. Y.
Bates, Onward......... Chicago, Ill.
Belknap, W. E........New York City
Benzenberg, G. H...Milwaukee, Wis.
Bergengren, F.......Harrisburg, Pa.
Berle, K ....Washington, D. C.
Berthelet, J. R..... Milwaukee, Wis.
Biddle, John..... Washington, D. C.
Black, William M..Washington, D. C.
Boller, A. P...........New York City
Boller, A. P., Jr .Brooklyn, N. Y.
Bolton, Channing M.........Rio, Va.
Bouscaren, G.......Cincinnati, Ohio
Braine, L. F...........Newark, N. J.
Breithaupt, W. H., Berlin, Ont., Canada
Brendlinger, P. F......Narberth, Pa.
Bryson, Andrew........Reading, Pa.
Buchholz, C. W.......New York City
Burr, Edward.....Washington, D. C.

Card, W. W...........Pittsburg, Pa.
Carlile, T. J........Philadelphia, Pa.
Carll, David S.....Washington, D. C.
Carter, Shirley........Richmond, Va.
Carter, William J....Cleveland, Ohio
Catt, George W.......New York City
Chambers, F. T....Philadelphia, Pa.
Chapin, L. E...........Canton, Ohio
Chase, R. D..........New York City
Chester, J. N..........Pittsburg, Pa.
Churchill, Chas. S......Roanoke, Va.
Clark, L. V.........Philadelphia, Pa.
Codwise, Edward B..Kingston, N. Y.
Codwise, H. R.......Brooklyn, N. Y.
Coffin, Amory.........New York City
Cohen, Mendes.......Baltimore, Md.
Cook, John H........Paterson, N. J.
Connor, E. H ...Leavenworth, Kans.
Corthell, A. B.........New York City
Craighill, William P., Washington, D. C.
Crane, Albert S., Sault Ste. Marie, Ont., Canada
Croes, J. J. R.........New York City
Creuzbaur, R. W......New York City
Crowell, F ....New York City
Cummings, Robert A..Pittsburg, Pa.

Dalrymple, F. W..Jamestown, N. Y.
Darrach, C. G. .....Ridley Park, Pa.
Davis, Arthur P...Washington, D. C.
Davis, Charles........Allegheny, Pa.
Davis, Harold.....Washington, D. C.
Davidson, George S....Pittsburg, Pa.
Dean, Luther........Taunton, Mass.
Deans, John S. ....Phœnixville, Pa.
Dennis, W. F.........Richmond, Va.
Douglas, E. M ...Washington, D. C.
Drake, A. B ....New Bedford, Mass.
Dunham, H. F.......New York City.
Dunn, E. C......... Alexandria, Va.

Easby, M. Ward....Philadelphia, Pa.
Ellis, John W......Woonsocket, R. I.
Endicott, Mordecai T., Washington, D. C.

Engle, R. L.... ....Cincinnati, Ohio
Erlandsen, Oscar .....New York City
Evans, M. E..........New York City

Fendall, B. T ....Baltimore, Md.
Fiebeger, G. J... .West Point, N. Y.
Fisher, Edwin A... Rochester, N. Y.
Fitch, C. H.......Washington, D. C.
Flad, Edward........ St. Louis, Mo.
Flynn, Benjamin H..Columbus, Ohio
Folwell, A. Prescott .....Easton, Pa.
Francis, Charles.... Davenport, Iowa
Freeman, Frank L..Washington, D. C.
Freyhold, Felix...Washington, D. C.
Frink, E. A..........Baltimore, Md.
Fuller, George W.....New York City
Fuller, William B.... Paterson, N. J.
Furber, W. C.......Philadelphia, Pa.

Gahagan, W. H......Brooklyn, N. Y.
Garrison, F. L ...Philadelphia, Pa.
Gartensteig, Charles. .New York City
Gates, Christopher L ..Toledo, Ohio
Gerig, William ..... Memphis, Tenn.
Gifford, George E.....New York City
Goad, C. E ..Montreal, Que., Canada
Goldsborough, J. B.,
Croton-on-Hudson, N. Y.
Goodell, J. M.......Worcester, Mass.
Gowen, Charles S....Ossining, N. Y.
Grafton, C. E...........Akron, Ohio
Graham, J. M ....Baltimore, Md.
Grantham, Herbert T.,
Philadelphia, Pa.
Gray, Samuel M ...Providence, R. I.
Green, Bernard R..Washington. D.C.
Greene, Charles E..Ann Arbor, Mich.
Greiner, John E......Baltimore, Md.
Griggs, Julian.......Columbus, Ohio
Guthrie, Edward B....Buffalo, N. Y.

Hagar, Edward M.......Chicago, Ill.
Haines, C. W.......Philadelphia, Pa.
Haines, H. S..........Detroit, Mich.
Hains, P. C ....Baltimore, Md.
Hall, Benjamin M.......Atlanta, Ga.
Hamlin, G. H............Orono, Me.
Hankinson, A. W.....New York City
Hanna, John H...Washington, D. C.
Hansel, Charles.......New York City
Harper, Isaac O.......Baltimore, Md.
Harrington, F. F....Brooklyn, N. Y.
Harris, C. M..........New York City
Harrison, E. W.....Jersey City, N. J.
Harrod, B. M......New Orleans, La.
Hartranft, W. G . Philadelphia, Pa.
Hatton, T. Chalkley,
Wilmington, Del.
Haupt, L. M.......Philadelphia, Pa.
Hayes, Edward....... Cohoes, N. Y.
Hayford, J. F.....Washington, D. C.
Hazen, Allen.........New York City
Hazlehurst, J. N........Mobile, Ala.
Hendricks, V. K..Indianapolis, Ind.
Hering, Rudolph......New York City
Herschel, Clemens... New York City
Hickok, H. A..........Newark, N. J.
Hider, Arthur......Greenville, Miss.
Hildenbrand, W......New York City
Hill, E. A........Washington, D. C.
Hodgdon, Frank W....Boston, Mass.
Honens, Fred W........Sterling, Ill.
Horton, Horace E.......Chicago, Ill.
Horton, Theodore....New York City
Hovey, O. E..........Pencoyd, Pa.
Howe, Horace J......New York City
Howell, D. J......Washington, D. C.
Hughes, W. M ....Chicago, Ill.
Humphreys, Richard L.
Philadelphia, Pa.
Hunt, Charles Warren.New York City
Hunt, Conway B..Washington, D. C.
Hunt, Robert W....... Chicago, Ill.
Hutton, N. H........Baltimore, Md.
Hyde, Charles G...Philadelphia, Pa.

Ingalls, O. L....Washington, D. C.

Johnson, A. L....... St. Louis, Mo.
Johnson, J. M....... Louisville, Ky.
Johnson, Lewis E .... Steelton, Pa.
Johnson, L. J......Cambridge, Mass.
Jordan, E. C..........Portland, Me.
Judson, William Pierson
Oswego, N. Y.
Judson, W. V....Washington, D. C.

Kenney, E. F..... Philadelphia, Pa.
Khuen, H., Jr.........Pittsburg, Pa.
Kimball, George A.... Boston, Mass.
King, Paul S ....New York City
Kingsley, M. W......Cleveland, Ohio
King, W., Jr..........New York City
Knap, J. M...........New York City
Knowles, Morris .... Pittsburg, Pa.
Kuichling, Emil....Rochester, N. Y.
Kutz, C. W...... .Washington, D. C.

La Chicotte, H. A....New York City
Latrobe, C. H........Baltimore, Md.
Latta, Harrison W..Philadelphia, Pa.
Leisen, Theodore A. Wilmington, Del.
Leland, W. A....... Columbia, S. C.
Leonard, H. R......Philadelphia, Pa.
Lepper, Fred W.. Washington, D. C.
Lesley, R. W......Philadelphia, Pa.
Lewerenz, A. C....Washington, D C.
Linton, Harvey ....Altoona, Pa.
Livingston, J. I.. Bound Brook, N. J.
Lockwood, Willard D.Baltimore, Md.
Long, E. McL..... New York City
Looker, H. B......Washington, D. C.
Loomis, Horace......New York City
Loree, L. F..........Baltimore, Md.
Low, George E.......New York City
Loweth, C. F...... Chicago, Ill.
Lowinson, Oscar......New York City
Ludlow, J. L........Winston, N. C.
Lum, D..........Washington, D. C.
Lusk, J. L........Washington, D. C.
Lynch, T. D..........Pittsburg. Pa.
Lyon, W. C......Washington, D. C.

McCalla, R. C.......Tuscaloosa, Ala.
McCann, Thomas H .Hoboken, N. J.
McComb, David E. Washington, D. C.
McKenney, C. A..Washington, D. C.
Mackenzie, Alexander
Washington, D. C.
McKenzie, T. H..Southington, Conn.
McKinstry, C. H..Washington, D. C.
McLain, L. R ...St. Augustine, Fla.
Maclennan, John D..Cleveland, Ohio
McMinn, Thomas J....New York City
Maignen, J. P. A...Philadelphia, Pa.
Manley, Henry........Boston, Mass.
Marburg, Edgar....Philadelphia, Pa.
Marden, Walter R..Philadelphia, Pa.
Marple, William M.....Scranton, Pa.
Matcham, Charles A..Allentown, Pa.
Matthes, Gerard H. Washington, D.C.
Maxwell, J. R.........Newark, Del.
Mead, Elwood....Washington, D. C.
Melville, George W.
Washington, D. C.
Marindin, H. L....Washington, D. C.
Meyer, Henry C., Jr...New York City
Miller, Alexander M.
Washington, D. C.
Miller, Spencer......New York City
Mills, Charles M ..Philadelphia, Pa.
Montfort, Richard....Louisville, Ky.
Montgomery, J. A. Birmingham, Ala.
Moore, Charles H....New York City
Moore, Robert........St. Louis, Mo.
Mordecai, A........Cleveland, Ohio
Morse, C. M..........Buffalo, N. Y.
Mosman, A. T....Washington, D. C.
Munroe, Hersey..Washington, D. C.
Myers, E. T. D., Jr..Richmond, Va.

Neumeyer, R. E.....Bethlehem, Pa.
Newell, F. H .....Washington, D. C.
Nicolson. G. L....Washington, D. C.
Noble, Alfred........New York City
North, Edward P....New York City
Norton, A. G......Wheeling, W. Va.

Ockerson, J. A........St. Louis, Mo.
O'Rourke, John F.... New York City
Owen, James ....Newark, N. J.

Pardee, James T....Cleveland, Ohio
Parker, A. McC .....New York City
Parmley, W. C .....Cleveland Ohio
Parsons, A. L.....Washington, D. C.
Pegram, George H....New York City
Pence, W. D.........Lafayette, Ind.
Perrilliat, Arsène...New Orleans, La.
Peterson, P. A.
Montreal, Que., Canada
Pew, Arthur.........Bainbridge, Ga.
Phillips, A. E....Washington, D. C.
Pinchot, Gifford...Washington, D. C.
Polk, William Anderson,
New York City

Pollock, C. D........Brooklyn, N. Y.
Pierce, William T......Boston, Mass.
Potter, Alexander.....New York City
Powell, A. V............Chicago, Ill.
Pratt, William Arthur,
Philadelphia, Pa.
Pressey, H. A.....Washington, D. C.
Prout, H. G..........New York City

Quick, Alfred M......Baltimore, Md.

Ramsey, Edmund P..Brooklyn, N.Y.
Reed, W. Boardman...New York City
Reynders, J. V. W....Harrisburg, Pa.
Richards, J. T.....Philadelphia, Pa.
Richardson, T. F.....Clinton, Mass.
Riggs, M. J............Toledo, Ohio
Ripley, T. M.........Marietta, Ohio
Rommel, George, Jr.,
Wilmington, Del.
Rousseau, H. H...Washington, D. C.
Russell, S. Bent.......St. Louis, Mo.
Ryder, Ely M. T..New Haven, Conn.

Sabin, A. H..........New York City
Schaub, J. W.......... Chicago, Ill.
Schermerhorn, L. Y.,
Philadelphia, Pa.
Schmitt, Ewald...Washington, D. C.
Schneider, C. C..... New York City
Seaman, Henry B....New York City
Shirreffs, Reuben....Richmond, Va.
Shryock, Joseph G.Philadelphia, Pa.
Smith, J. Waldo......Paterson, N. J.
Smith, Oberlin... Bridgeport, N. J.
Soper, G. A ....New York City
Sperry, H. M.........New York City
Stauffer, D. McN.....New York City
Stern, E. W..........New York City
Swain, George F.......Boston, Mass.
Sweet, Elnathan.......Albany, N. Y.
Sweitzer, N. B....Washington, D. C.
Swensson, Emil.......Pittsburg, Pa.

Taber, George A......New York City
Tait, John G.........New York City
Tenney, George O.,
Spartanburg, S. C.
Thacher, Edwin......New York City
Thackray, George E..Johnstown, Pa.
Theban, J. G.........New York City
Thomas, George E...Annapolis, Md.
Thompson, Benjamin,
Chattanooga, Tenn.
Thompson, W. A...Washington, D. C.
Tinkham, S. E........Boston, Mass.
Trautwine, John C., Jr.,
Philadelphia, Pa.
Tullock, A. J....Leavenworth, Kans.
Turner, E. K..........Boston, Mass.

Ulrich, Daniel........New York City

Van Horne, John G...New York City
Vredenburgh, Watson, Jr.,
New York City

Wagner, J. C.......Philadelphia, Pa.
Wagner, S. T .....Philadelphia, Pa.
Wallace, W. M....Washington, D. C.
Warman, F. C....Washington, D. C.
Watkins, J. E.....Washington, D. C.
Warder, J. H ....Chicago, Ill.
Watson, William......Boston, Mass.
Webster, G. S......Philadelphia, Pa.
Webster, William R.,
Philadelphia, Pa.
Wegmann, E.........Katonah, N. Y.
Weller, Francis R. Washington, D. C.
Wentworth, C. C.......Roanoke, Va.
Weston, R. S.........Boston, Mass.
Whelpley, J. R...Washington, D. C.
Whistler, John T..Washington, D. C.
Whitcomb, H. D.....Richmond, Va.
White, F. G ....New York City
Whitted, L. R..........Norfolk, Va.
Whittemore, W. F....Hoboken, N. J.
Whitson, Abraham U.,
College Point, N. Y.
Wilcock, Frederick...Brooklyn, N.Y.
Wilkins, W. G........Pittsburg, Pa.
Wiley, W. H..........New York City
Williams, Gardner S ...Ithaca, N. Y.
Wills, A. J ....Harrisburg, Pa.
Wilson, C. A....... Cincinnati, Ohio
Wilson, H. M....Washington, D. C.
Wilson, Percy H...Philadelphia, Pa.

Wisner, George Y.....Detroit, Mich.
Wölfel, Paul L.........Pencoyd, Pa.
Worcester, J. R.......Boston, Mass.
Worthington, Charles..Pittsburg, Pa.
Wright, M. H.......Nashville, Tenn.
Yonge, Samuel H....Richmond, Va.

Zeller, A. H..........St. Louis, Mo.
Zipperlein, Joseph W., Philadelphia, Pa.

The total registered attendance at the Convention was as follows:

Members of the Society, in all grades	343
Guests, including ladies	377
Total	720

ANNOUNCEMENTS.

☞The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

MEETINGS.

Wednesday, September 3d, 1902.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and a paper by R. C. McCalla, M. Am. Soc. C. E., entitled "Improvement of the Black Warrior, Warrior and Tombigbee Rivers, in Alabama," will be presented for discussion.

This paper was printed in the *Proceedings* for April, 1902.

Wednesday, September 17th, 1902.—8.30 P. M.—At this meeting, a paper by James N. Hazlehurst, M. Am. Soc. C. E., entitled "The Maintenance of Asphalt Streets," will be presented for discussion.

This paper was printed in the *Proceedings* for May, 1902.

Wednesday, October 1st, 1902.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and a paper by Theron A. Noble, M. Am. Soc. C. E., entitled "The Flow of Water in Wood Pipes," will be presented for discussion.

This paper is printed in this number of *Proceedings*.

Wednesday, October 15th, 1902.—8.30 P. M.—At this meeting, a paper, entitled "The Protection and Improvement of Foreshores by the Utilization of Tidal and Wave Action," by R. G. Allanson-Winn, M. Inst. C. E., I., will be presented for discussion.

This paper is printed in this number of *Proceedings*.

ACCESSIONS TO THE LIBRARY.

From May 7th to August 5th, 1902.

DONATIONS.*

ELECTRIC POWER TRANSMISSION.

A Practical Treatise for Practical Men. By Louis Bell, M. Am. Inst. E. E. Third Edition, Revised and Enlarged. Cloth, 9½ x 6½ ins., 632 pp., illus., 21 plates. New York, Electrical World and Engineer, 1901. $3.00.

This volume is designed to set forth in the simplest possible manner the fundamental facts concerning present practice in electrical transmission. The author has endeavored, in introducing such theoretical considerations as are necessary, to explain them in the most direct way practicable, using proximate methods of proof and stating only the results of investigation when the processes are complicated. In order to bring the present edition up to date it became necessary almost to rewrite some of the chapters, adding considerable amounts of new matter and many illustrations of recent plants and apparatus. A brief chapter on commercial electrical measurements has been added, and a final chapter on the present state of high voltage transmission has been utilized to bring the latest developments of the art before the reader. The contents are: Elementary Principles; General Conditions of Power Transmission; Power Transmission by Continuous Currents; Some Properties of Alternating Circuits; Power Transmission by Alternating Currents; Synchronous and Induction Motors; Current Reorganizers; Engines and Boilers; Water Wheels; Hydraulic Development; The Organization of a Power Station; The Line; Line Construction; Centers of Distribution; The Commercial Problem; The Measurement of Electrical Energy; The Present State of High Voltage Transmission. There is an index of six pages.

THE MECHANICS OF ENGINEERING.

Volume II. The Stresses in Framed Structures, Strength of Materials and Theory of Flexure; also the Determination of Dimensions and Designing of Details, Specifications, Complete Designs and Working Drawings. By A. Jay Du Bois. Cloth, 11½ x 8 ins., 23 + 609 pp., illus., 28 plates. New York, John Wiley & Sons, 1902. $10.00.

The present (twelfth) edition of the author's "Stresses in Framed Structures" is issued as Vol. II of "The Mechanics of Engineering," of which Vol. I has already appeared. The present volume is complete in itself. The entire work has been revised, although but few changes from the last edition have been made. The contents are: Part I. Different Methods of Calculation; Practical Application of Preceding Methods to Various Structures; Part II. Determination of Dimensions and Designing of Details. There is an index of seven pages.

METALLURGY OF CAST IRON.

A Complete Exposition of the Processes Involved in its Treatment, Chemically and Physically, from the Blast Furnace through the Foundry to the Testing Machine. A Practical Compilation of Original Research. By Thomas D. West. Sixth Edition. Cloth, 7 x 5 ins., 20 + 627 pp., illus. Cleveland, The Cleveland Printing and Publishing Co., 1902. $3.00. (Donated by the author.)

This work is written with a view to its value not only to the founder, the moulder, the blast-furnace man, the chemist and the engineer, but also to the designer, the draftsman, the pattern maker, the college specialist and all who may in any manner be desirous of obtaining a practical knowledge of cast iron in its application to founding or any allied interests. In compiling this volume, the author has been guided by a broad experience as a moulder and founder in loam, dry and green sand, and in the various specialties of founding. The work has been extensively revised, and much new matter on making, mixing, melting and testing cast iron has been added. Part I treats of Man-

* Unless otherwise specified, books in this list have been donated to the Library by the Publisher.

ufacture and Use of Coke: Properties in Ores; Operations of Blast Furnaces; The Different Brands of Pig Iron and How to Purchase and Use Them Intelligently. Part II treats of Elements in Cast Iron and Their Physical Effects; Utility of Chemical Analyses and How to Use Them in making the Different Mixtures of Irons Used in making Gray and Chilled Castings. Part III treats of Properties of and Methods for Testing Molten Iron; Discloses Phenomena in the Actions of Cooling Metal, etc.; Presents Results of Tests in All Kinds of Irons, and the Best Methods for Testing. There is an index of thirty-three pages.

ANNUAL STATISTICAL REPORT OF THE AMERICAN IRON AND STEEL ASSOCIATION.

Containing Complete Statistics of the Iron and Steel Industries of the United States for 1901 and Preceding Years. Paper, 9¼ x 6 ins., 64 pp. Philadelphia, American Iron and Steel Association, 1902. $3.00.

This work gives full details of the production of iron ore and the various forms of iron and steel in the United States in 1900, and immediately preceding years, the shipments of iron ore from the Lake Superior and other mines, the imports of Cuban and other iron ore, the production of coal and coke, the imports and exports of iron and steel and coal and coke, the production of manganese ore, the prices of Lake Superior iron ore, the prices of iron and steel, the tonnage of iron and steel vessels built in 1900 and 1901, immigration in 1900, etc.

Forming a part of the report is a paper, prepared for the United States Geological Survey, which is devoted to a review of the progress made by the world's iron and steel industries down to the close of the Nineteenth Century. A feature of this paper is a chronological record of the development of the iron and steel industries of the United States from 1619 to 1900, giving the principal events in that development and a summary of the results.

THE EVOLUTION OF MINE-SURVEYING INSTRUMENTS.

By Dunbar D. Scott and Others. Comprising the Original Paper of Mr. Scott on the Subject, together with the Discussion thereof, and Independent Contributions on the Subject. Cloth, 9 x 5 ins., 324 pp., illus. New York City, American Institute of Mining Engineers, 1902. $3.50.

In this volume the Secretary of the Institute has gathered the several papers and discussions on mine-surveying instruments which have been contributed to the recent volumes of the *Transactions*. The preface states that "the subject will never be exhausted. It is believed, nevertheless, that the material here presented comprises in compact and convenient form information of sufficient scope and value to warrant the issue of the book by the Institute."

THE MUNICIPAL YEAR BOOK, 1902.

Giving the Population, Assessed Valuation, Principal Officials and Ownership of Public Utilities; also information regarding the Water Supply, Sewerage, Street Cleaning, Street Sprinkling, Garbage, Fire and Underground Electric Service in all Incorporated Places in the United States, and in all New England Towns of 3 000 Population and Upwards by the Census of 1900. With Summaries and Editorial Discussion. Edited by M. N. Baker. Cloth, 9 x 6 ins., 54 + 310 pp. New York, The Engineering News Publishing Company, 1902. $3.00.

This book combines a directory of municipal officials and franchise companies, an exhibit of municipal and private ownership, and an outline of the leading public works and services in each of the 1 524 largest municipalities of the country. The preface states that never before has there been presented so complete an exhibit of the relative extent of municipal and private ownership. This information is first given alphabetically by States, together with other facts relating to the various cities and towns. It is next presented alone, in compact tabular form, with cities arranged in order of population, from Greater New York, with 3 437 202, to Rice Lake, Wis., with 3 002 inhabitants. Various summaries, by geographical location and by population, follow.

HANDBOOK FOR STREET RAILWAY ENGINEERS.

Containing Geometrical and Trigonometrical Formulæ, Transition Curve Tables, Track Construction Tables, Strength of Wooden Beams and Columns, Electrical Formulæ and Tables, and much other Infor-

mation Invaluable in Street-Railway Design and Maintenance. By H. B. Andrews. Leather, 5 x 3 ins., 202 pp., plates. New York, John Wiley & Sons, 1902.

In preparing this book, it has been the desire of the author to present in compact form a collection of tables and information particularly suitable for use by engineers connected with street railways. The author, during his connection with the Boston Elevated Railway Company for the past eleven years, has computed and tabulated much of the information given. The remainder has been compiled from various sources, selecting only that which would be of the most practical value in every-day work. All tables, diagrams, formulas, etc., have been carefully verified, and it is believed they are free from errors of any magnitude. The chapter headings are: Mensuration—Trigonometrical Formulæ; Circular Curves; Compound Transition Curves; Plain Curves; Miscellaneous Information; Bending Moments, Strength of Materials; Data for Estimates; Electrical Information; Aluminum for Electrical Conductors; The Storage Battery; Tables; Relative Percentages of Expenditures to Gross Receipts for Street Railways in Massachusetts; Buyer's Directory.

PRINCIPLES OF SANITARY SCIENCE AND PUBLIC HEALTH.

With Special Reference to the Causation and Prevention of Infectious Diseases. By William T. Sedgwick. Cloth, 9 x 6 ins., 19 + 368 pp., plates. New York, The Macmillan Company, 1902. $3.00.

This volume is a direct outgrowth of a course of lectures on Sanitary Science and Public Health, given for several years by the author to certain senior students of the Massachusetts Institute of Technology, and it has been prepared primarily for their use. It is believed, however, that a larger circle of students and some physicians, publicists and general readers may be glad to have access to the same material. The author states that the volume deals with principles, rather than the arts, of sanitation; nor is it based upon lectures given to beginners. It is intended to be no more than an elementary treatise on the subject; and while it is believed that it contains some new material, and some old material treated from new points of view, no special claim is made for originality either in substance or in method of presentation. The author has chiefly sought to bring together and present in a simple and logical form those fundamental principles on which the great practical arts of modern sanitation securely rest. The chapter headings are: On Health, Old Age and Disease; On Ætiology or Causes of Disease; On the Rise and Influence of Bacteriology; Sanitary Aspect of the Struggle for Existence; On Infection and Contagion; On Dirt and Disease; On Sewage as a Vehicle of Infectious Disease; On Water as a Vehicle of Infectious Disease; On the Establishment and Conservation of Purity of Public Water Supplies; On Ice as a Vehicle of Infectious Disease; On Milk as a Vehicle of Infectious Disease; On Certain Uncooked Foods as Vehicles of Infectious Disease; On the Prevention and Inhibition of Infection, Decomposition and Decay; On the Destruction or Removal of Infection; On Some Popular Beliefs as to Certain Special and Peculiar Causes of Disease. There is an index of six pages.

SEWAGE WORKS ANALYSES.

By Gilbert J. Fowler. Cloth, 7½ x 5½ ins., 6 + 135 pp., illus. New York, John Wiley & Sons, 1902. $2.00.

This book has been written in response to several requests for an account of the methods of analysis in use in the laboratory of the Manchester Corporation Sewage Works. The author has also been able to include descriptions of some of the more important processes employed in the laboratory of the Mersey and Irwell Joint Committee. The preface states that, in general, the Joint Committee's methods are designed for cases where samples from different works have to be critically examined, the Manchester methods for the analysis of a large number of samples of sewage and effluents of the same general character. It is believed that the methods here described are such as a considerable experience has shown to be capable of being rapidly executed, and of giving results of an accuracy amply sufficient for practical requirements. The Contents are: The Chemical Control of Sewage Purification Processes; The Determination of Absorbed Oxygen; The Determination of Ammonia; The Determination of Nitrites and Nitrates; The Determination of Dissolved Oxygen; The Determination of Chlorine, Acidity and Alkalinity, and Iron Compounds; The Determination of Solids in Solution and Suspension; The Analysis of Gases from the Septic Tank and from Bacterial Filters; Tables. There is an index of two pages.

STEAM HEATING AND VENTILATION.

By William S. Monroe, M. Am. Soc. M. E. Cloth, 9½ x 6 ins., 146 pp., illus. New York, The Engineering Record, 1902. $2.00.

It has been the aim of the author, in this work, to present briefly the theoretical considerations involved in the design of heating and ventilating plants, and to compile the best of the large array of empirical formulas and data in a way that will be of value to

those interested in the current practice of the art. The Contents are: Steam Heating; Systems of Piping and Steam Supply; Steam Heating Apparatus; Indirect Radiators; Design of Radiation; Piping and Construction Details; Mechanical Ventilation—General Principles; Systems of Mechanical Ventilation; Ventilating Ducts; Ventilating Fans; Heaters and Other Apparatus. There is an index of three pages.

LA CONSTRUCTION EN CIMENT ARMÉ.

Applications Générales, Théories et Systèmes Divers. Par C. Berger et V Guillerme. Préface de E. Candlot. 2 vol. Paper, 10 x 6½ ins. (Atlas 12 x 9½). Paris, Ch. Dunod, 1902. 40 francs.

The authors have endeavored in this work to impart information concerning the principles and advantages of "ciment armé," the different systems advocated, the judicious use of materials, etc. They believe that the exposition of theories and methods of calculation, the description of the processes of execution and their many applications, together with the numerous drawings and detailed designs, make this book a practical treatise, interesting alike to the theorist, the engineer and the architect. The contents are: Chaux et Ciments; Le Ciment Armé; Méthodes et Procédés Divers.

NEUERE BAUWEISEN UND BAUWERKE AUS BETON UND EISEN.

III. Theil, Fortsetzung des Berichtes über den Stand bei der Pariser Ausstellung aus dem Gebiete des Wasserbaues; Der Expertenbericht über den Hauseinsturz in Basel. IV. Theil. Die Durchbiegung und Einspannung von armierten Betonbalken und Platten. Von Fritz von Emperger. Paper, 14 x 10 ins., 55 pp., illus. Wien, Lehmann & Wentzel, 1902.

WATER-SUPPLY.

(Considered Principally from a Sanitary Standpoint.) By William P. Mason. Third Edition, Rewritten. Cloth, 9 x 6 ins., 7 + 448 pp., illus., maps. New York, John Wiley & Sons, 1902. $4.00.

The preface states that as so much material has been added to the stock of general knowledge upon the subject of "Water-supply" since the appearance of the last edition of this book it was found necessary to rewrite large portions of the original text. The chapters upon the "Chemical and Bacteriological Examination of Water" have been omitted, for the reason that they have been published separately in book form for the more convenient use of students. Under Filtration will be found a full account of the workings of the new plants at both Albany and Ashland, together with statistics illustrating the results of such filtration upon typhoid death-rates. Considerable new material will be found under the subject of Mechanical Filtration, including a discussion of the new iron coagulant and also the influence of sedimentation-basins when the filter is running upon soft water. Space is also given to a discussion as to the merits of the rival systems of filtration, American and English, and to the question of properly choosing between them for municipal filtration. Purification of water by freezing and underground storage are largely dealt with. All statistical tables are carried up to date and many new illustrations are given. The chapter headings are: Introductory; Drinking-Water and Disease; Artificial Purification of Water; Natural Purification of Water; Rain, Ice and Snow; River and Stream-Water; Stored Water; Ground-Water; Deep-Seated Water; Quantity of Per Capita Daily Supply; Action of Water upon Metals; Analyses of City Water-Supplies; Typhoid-Fever Death-Rates for American Cities; Typhoid-Fever Statistics for American and European Cities; Effects of Contaminated Waters upon Fish; Water for Industrial Purposes; Liquids Deemed Polluting by English River Pollution Commission; Use of Sea-Water for Street-Washing, Sewer-Flushing, etc. There is an index of twenty-two pages.

DIAGRAMS OF MEAN VELOCITY OF UNIFORM MOTION OF WATER IN OPEN CHANNELS.

Based on the Formula of Ganguillet and Kutter. Prepared by Irving P. Church, C. E. Paper, 9½ x 12½ ins., unpaged. New York, John Wiley & Sons, 1902. $1.50.

This is a set of eleven diagrams for different values of n, from 0.009 to 0.035, and ranging from 0.1 ft. to 25 ft. in the value of R, the hydraulic radius; the slope varying from 0.01 ft. to 100 ft. per thousand (that is, from $S = 0.00001$ to $S = 0.100$). "Such being the range of application, covering all ordinary cases in practice, it is thought that these diagrams constitute a fairly comprehensive 'bird's eye view' of Kutter's useful formula."

The following gifts have also been received:

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Le Ciment (to complete set). 6 vol.

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PFEIFER, HERMAN JULIUS.............Engr., M. of W., Terminal R. R. Association of St. Louis; St. Louis Merchants' Bridge Terminal Ry., 206 Union Station, St. Louis, Mo.

POLAND, WILLIAM BABCOCK...........Div. Eng., Pittsburg Div., B. & O. R. R., Iroquois Apartments, Pittsburg, Pa.

RACE, JOHN MARBLE..................Housatonic, Mass.

RUSSELL, RICHARD LORD.............149 Ashland Pl., Brooklyn, N. Y.

STICKNEY, GEORGE FETTER............Selma, Ala.

STOWE, HAROLD CLAIR................(Clarke, Wright & Stowe, Contr. Engrs.), 232 Kent St., Brooklyn, N. Y.

THOMPSON, CLARK WALLACE..........Vice-Pres., Wind River Lumber Co., Cascade Locks, Ore.

THROOP, AUGUSTUS THOMPSON.........Mgr., A. T. Throop & Co., Cons. and Contr. Engrs., Erie Co. Bank Bldg., Buffalo, N. Y. (Res., 706 Buffalo Ave., Niagara Falls, N. Y.)

URQUHART, GEORGE COPELAND.........Asst. Real Estate Agt., Pennsylvania Lines West of Pittsburg, 1104 Union Station, Pittsburg, Pa.

VILLALON, JOSÉ RAMON...............Camp Columbia, No. 13, Marianao, Cuba.

WALKER, JOSEPH MILTON.............Chf. Engr., Mahoning Valley Ry. Co., Youngstown, Ohio.

WIGGIN, THOMAS HOLLIS..............Care, Leonard Metcalf, 14 Beacon St., Boston, Mass.
WIGGINS, WILLIAM D..................Engr., M. of W., Toledo Div., Pennsylvania Lines, Toledo, Ohio.
WILKES, JAMES KNAPP................Hotel McDonough, Middletown, Conn.
WILLIAMS, CHARLES PAGE.............U. S. Engr. Office, New London, Conn.
ZARBELL, ELMER......................Selma, Ala.

ASSOCIATES.

ABBOTT, EDWARD LORENZO...........71 Broadway, Room 612, New York City.
BOOTH, WILLIAM FERRIS..............Cons. Engr., Transit Finance Co., 170 Broadway, New York City.
DAVIS, JOHN WOODBRIDGE.............523 West 173d St., New York City.
GRAHAM, WILLIAM WOODMAN.........Care, American Bank, City of Mexico, Mexico.
LINDENBERGER, CASSIUS HOWARD.....Defiance, Ohio.
PIPER, ALEXANDER ROSS..............Capt., U. S. A., Retired, 85th St., Bay Ridge, Brooklyn, N. Y.
TURRILL, SHERMAN MARSH...........Insp., Western Div., N. Y. C. & H. R. R. R., Dresden, N. Y.

JUNIORS.

BEEKMAN, JOHN VAN DERVEER, Jr....101 Tremont St., Boston, Mass.
CÁCERES, SIMON NOVELO..............Box 255, National City, Cal.
CAMERON, JOHN BOBBS................Asst. Div. Engr., B. & O. R. R., Chillicothe, Ohio.
CHADBOURN, WILLIAM HOBBS, Jr.......U. S. Engr. Office, Wheeling, W. Va.
CORRIGAN, GEORGE WASHINGTON.......Res. Engr., St. Louis, Iron Mountain & Southern Railway, Arkana, Baxter Co., Ark.
CRANE, WILL EDWIN.................18 Broadway, Room 803, New York City.
ENZIAN, CHARLES.....................171 North Franklin St., Wilkesbarre, Pa.
FARGUSSON, MARK ....236 West 45th St , New York City.
FORD, WILLIAM HAYDEN..............The Beaucaire, Haddington, Pa.
GOODRICH, ERNEST PAYSON...........Chf. Engr., Bush Terminal Co., Coffee Exchange Bldg., Hanover Sq., New York City.
GRAVES, WILLARD FRANKLIN..........Gen. Mgr. and Treas., Le Bosquet Coal & Mining Co., Hughes, Ind. T.
HOWARD, ERNEST EMMANUEL..........Care, Waddell & Hedrick, 608 New Nelson Bldg., Kansas City, Mo.
MACCREA, DON ALEXANDER...........Care, C., O. & G. R. R. Co., Guthrie, Okla. T.
MCFETRIDGE, WILLIAM SUTTON ....Care, Little Kanawha R. R., Parkersburg, W. Va.
MERZ, LEON...... ....................S.W. Cor. Third and Brown Sts., Philadelphia, Pa.

Monsarrat, Nicholas Daubeney.....Supt., Kanawha & Hocking Coal & Coke Co., Longacre, W. Va.
Morphy, Luis Gonzaga..............Room 512, Grand Central Station, New York City.
Nutter, Charles Herbert...........130 West 118th St., New York City.
Raynor, Clarence Webster.........Box 385, Kansas City, Mo.
Skelly, James William.............U. S. Engr. Depot, Foot of Arsenal St., St. Louis, Mo.
Spencer, Louis Bernard............Care, Chf. Engr., C., C., C. & St. L. Ry., Cincinnati, Ohio.
Thompson, Wilford Ashford........1641 Thirteenth St., N. W., Washington, D. C.
Tilt, Garret Edward...............688 East 25th St., Paterson, N. J.
Van Brakle, John Ogden...........Dept. of Docks and Ferries, Pier A, North River, New York City.
Van Loan, Seth Morton.............Asst. Engr., Belmont Filter Plant, 2525 Belmont Ave., Philadelphia, Pa.
Van Pelt, Sutton....................Care, U. S. Engr., Demopolis, Ala.
Van Zile, Harry Lee................410 West End Ave., New York City.
Wells, Clinton Glencairn..........City Engr., City Hall, Galveston, Tex.
Whitney, Thomas Bryan, Jr.........43 West 34th St., New York City.
Widdicombe, Robert Alexander.....Engr. and Supt., Kroeschell Bros. Co., 55 Erie St., Chicago, Ill.
Wilgus, Herbert Sedgwick.........Asst. Engr., Track Elevation, P., Ft. W. & C. Ry., Cor. Laycock and Hope Sts. (Res., 1206 Boyle St.), Allegheny, Pa.
Williams, Roger Butler, Jr........812 Monadnock Blk., Chicago, Ill.
Young, Henry Amerman............ 110 Ravine Ave., Yonkers, N. Y.

DEATHS.

Blake, Edward Josiah...............Elected Member, April 3d, 1889; died May 29th, 1902.
Hobby, Arthur Stanley.............Elected Member, June 6th, 1894; died May 28th, 1902.
Howe, Milton Grosvenor............Elected Member, October 16th, 1872; died June 19th, 1902.
Johnson, John Butler...............Elected Member, April 7th, 1886; died June 23d, 1902.
Lincoln, William Shattuck.........Elected Member, December 5th, 1883: died May 16th, 1902.
Milne, Peter........................Elected Associate, January 7th, 1896; died June 9th, 1902.
Shaler, Ira Alexander..............Elected Junior, July 4th, 1888; Member June 5th, 1895; died June 29th, 1902.
Temple, Robert Henry..............Elected Member, May 6th, 1885; died December 23d, 1901.
Whitford, Oscar F..................Elected Member, December 6th, 1871; died May 21st, 1902.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST.

(May 7th to August 5th, 1902.)

NOTE.—*This list is published for the purpose of placing before the members of the Society the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS.

In the subjoined list of articles references are given by the number prefixed to each journal in this list.

(1) *Journal*, Assoc. Eng. Soc., 257 South Fourth St., Philadelphia, Pa., 30c.
(2) *Proceedings*, Eng. Club of Phila., 1122 Girard St., Philadelphia, Pa.
(3) *Journal*, Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal*, Western Soc. of Eng., Monadnock Block, Chicago, Ill.
(5) *Transactions*, Can. Soc. C. E., Montreal, Que., Can.
(6) *School of Mines Quarterly*, Columbia Univ., New York City, 50c.
(7) *Technology Quarterly*, Mass. Inst. Tech., Boston, Mass., 75c.
(8) *Stevens Institute Indicator*, Stevens Inst., Hoboken, N. J., 50c.
(9) *Engineering Magazine*, New York City, 25c.
(10) *Cassier's Magazine*, New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 35c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News*, New York City, 15c.
(14) *The Engineering Record*, New York City, 12c.
(15) *Railroad Gazette*, New York City, 10c.
(16) *Engineering and Mining Journal*, New York City, 15c.
(17) *Street Railway Journal*, New York City, 35c.
(18) *Railway and Engineering Review*, Chicago, Ill., 10c.
(19) *Scientific American Supplement*, New York City, 10c.
(20) *Iron Age*, New York City, 10c.
(21) *Railway Engineer*, London, England, 25c.
(22) *Iron and Coal Trades Review*, London, England, 25c.
(23) *Bulletin*, American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gas Light Journal*, New York City, 10c.
(25) *American Engineer*, New York City, 20c.
(26) *Electrical Review*, London, England.
(27) *Electrical World and Engineer*, New York City, 10c.
(28) *Journal*, New England Water-Works Assoc., Boston, $1.
(29) *Journal*, Society of Arts, London, England, 15c.
(30) *Annales des Travaux Publics de Belgique*, Brussels, Belgium.
(31) *Annales de l' Assoc. des Ing. Sortis des Ecôle Spéciales de Gand*, Brussels, Belgium.
(32) *Mémoires et Compte Rendu des Travaux*, Soc. Ing. Civ. de France, Paris, France.
(33) *Le Génie Civil*, Paris, France.
(34) *Portefeuille Économique des Machines*, Paris, France.
(35) *Nouvelles Annales de la Construction*, Paris, France.
(36) *La Revue Technique*, Paris, France.
(37) *Revue de Mécanique*, Paris, France.
(38) *Revue Générale des Chemins de Fer et des Tramways*, Paris, France.
(39) *Railway Master Mechanic*, Chicago, Ill., 10c.
(40) *Railway Age*, Chicago, Ill., 10c.
(41) *Modern Machinery*, Chicago, Ill., 10c.
(42) *Transactions*, Am. Inst. Elec. Eng., New York City, 50c.
(43) *Annales des Ponts et Chaussées*, Paris, France.
(44) *Journal*, Military Service Institution, Governor's Island, New York Harbor, 50c.
(45) *Mines and Minerals*, Scranton, Pa., 20c.
(46) *Scientific American*, New York City, 8c
(47) *Mechanical Engineer*, Manchester, England.
(58) *Proceedings*, Eng. Soc. W. Pa., 410 Penn Ave., Pittsburg, Pa., 50c.
(59) *Transactions*, Mining Inst. of Scotland, London and Newcastle-upon-Tyne.
(60) *Municipal Engineering*, Indianapolis, Ind., 25c.
(61) *Proceedings*, Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *American Manufacturer and Iron World*, 59 Ninth St., Pittsburg, Pa.
(63) *Minutes of Proceedings*, Inst. C. E., London, England.
(64) *Power*, New York City, 20c.
(65) *Official Proceedings*, New York Railroad Club, Brooklyn, N. Y., 15c.
(66) *Journal of Gas Lighting*, London England, 15c.
(67) *Cement and Engineering News*, Chicago, Ill., 25c.

Bridge.

The Great Luxembourg Arch. (12) May 2.
Cable Making on the New East River Bridge.* (20) May 8.
Design of Concrete-Steel Arch Bridge.* Daniel B. Luten. (13) May 8.
The Luxembourg Bridge from the View-Point of an American Designer of Masonry Arch Bridges.* (13) May 8.
A Heavy Double-Track Skew Bridge.* (14) May 10.
Single-Track Plate-Girder Railroad Bridges at Richmond, Ind.* (14) May 17.
Allegheny River Bridge and Track Elevation at Pittsburgh.* (15) May 28.
Moving the Fort Wayne Bridge.* (14) May 31.
Examples of Bridge Calculations. (21). Serial beginning June.
The Distribution of Rivets in Iron and Steel Bridges. (21) Serial beginning June.
Reinforcing a Railroad Bridge in Service.* (15) June 14.
Bridge over the Mississippi River at Thebes, Ill.* (40) June 20.
The Desirability of Using a Single Grade of Steel for Bridges. (13) June 26.
Bascule Bridge at Grand Ave., Milwaukee, Wis.* (13) July 3; (14) July 12.
Moving the New Brunswick Bridge.* (40) July 4; (14) July 5.
The Ohio River Bridge at Marietta, Ohio.* (15) July 11.
An Important Bridge Renewal.* (40) July 11.
Recent Progress in American Bridge Construction. Henry S. Jacoby. (13) July 17; (19) July 19.
The Royal Alexandra Bridge at Ottawa.* H. D. Bush, M. Am. Soc. C. E. (15) July 18.
The Westchester Avenue Rolling Bridge, New York.* (14) July 26.
Design of a Concrete-Steel Arch Culvert.* David B. Luten. (15) Aug. 1.
Étude de la Déformation Élastique dans les Pièces Comprimées Horizontales.* E. Lebert. (43) 1er Trimestre.
Note sur le Calcul des Arcs Métalliques Surbaissés de Section Peu Variable Reposant sur des Clavettes aux Retombées.* M. L. de Boulongne et M. Bedaux. (43) 1er Trimestre.
Note sur les Calculs de Stabilité des Ponts en Arcades du Système Vierendeel. Ed. Joyant. (30) Apr.
Analyse des Observations Faites sur Divers Ponts Métalliques de la Compagnie d' Orléans au Moyen des Appareils de M. Rabut. M. Lanna. (38) Serial beginning May.
Notice sur la Construction de Sept Ponts à Poutres Continues sur les Canaux de Selzaete à la Mer du Nord et de Dérivation de la Lys. A. de Somer. (30) June.
Fondations par Caissons à Air Comprimé.* Grimaud. (36) Serial beginning June 25.

Electrical.

Mechanical Speed Changing Devices. Driving Machine Tools from Constant Speed Motors. (58) May.
The Electric Motor in Mill Work. S. S. Wales. (58) May.
Some Characteristics of Direct Current Motors. Norman Wilson Storer. (58) May.
The Use of the Electric Motor in Modern Blast Furnace Plants. Andrew Ellicott Maccoun. (58) May.
Electric Equipment in Modern Machine Shop Practice. F. B. Duncan. (58) May.
The Karlsruhe Electricity Works.* (26) May 2.
The Manufacture of Glow Lamps.* (26) Serial beginning May 9.
The Electrical Equipment of the Experimental Model Basin at Washington Navy Yard.* J. Adgar McCrary. (27) May 10.
The Genesis of Wireless Telegraphy. A. Frederick Collins. (27) May 10.
The Isolated Plant *versus* the Central Station—Discussion at the Chicago Electrical Association. (27) May 10.
The English Electro-Metallurgical Company, Limited.* (11) May 16.
Electric Power Installation at the Ougrée Works, Belgium.* (22) May 16.
The Cincinnati Gas and Electric Company.* (27) May 17.
Transformer Testing by Central Station Companies. R. F. Schuchardt. (27) May 17.
The Field of Force in Wireless Telegraphy. Lee de Forest. (27) May 17.
Synchronous Motor Calculations. F. G. Baum. (27) May 17.
Electrically Operated Cranes and Methods of Control.* Frank C. Perkins. (62) May 22.
Electric Installation at the Upper Forest and Worcester Steel and Tinplate Works.* (22) May 23.
The Bergen County, N. J., Lighting System.* W. J. Jones. (27) May 24.
The Buckingham Long-Distance Page-Printing Telegraph.* William Maver, Jr. (27) May 24.
The Incandescent Electric Lamp—How Manufactured and Tested.* (19) May 24.
Creosoting Wooden Poles for Electric Line Work. W. E. Moore. (13) May 29.
Recent Construction, Atlantic Ave. Station, Edison Electric Illuminating Co., Boston.* I. E. Moultrop and R. E. Curtis. (Paper presented at the Convention of the Am. Soc. Mech. Engrs.) (14) May 31.
The Guarini Automatic Wireless Telegraph Repeater.* A. Frederick Collins. (27) May 31.
Telpherage.* Charles M. Clark. (1) June.
The Real Nature of Electricity and Magnetism. Arthur A. Skeels. (1) June.
Success in Long-Distance Power Transmission. F. A. C. Perrine. (7) June.
The 50 000-Volt Transmission Plant of the Missouri River Power Company.* W. G. McConnon. (13) June 5; (27) June 7; (16) June 7; (14) June 7.

* Illustrated.

Electrical—Continued.

The Atlantic Avenue Station of the Boston Edison Electric Illuminating Co.* I. E. Moultrop and R. E. Curtis. (Abstract of Paper read before Amer. Soc. Mech. Engrs.) (13) June 5.
Some Notes on Polyphase Machinery.* A. C. Eborall. (Paper read before the Manchester Section of Inst. of Elec. Engrs.) (11) Serial beginning June 6.
The Cauveri Falls Electrical Power Transmission.* (12) Serial beginning June 6.
Automatic Relay Translation for Long Submarine Cables. S. G. Brown. (Read before the Inst. of Elec. Engrs.) (26) Serial beginning June 6.
New Electric Lighting Plant for Ottawa, Canada.* A. A. Dion. (27) June 7.
The Possibilities for a Light-Weight Storage Battery. A. L. Marsh. (27) June 7.
Protection of Long Distance Transmission Lines. Charles H. Baker. (Abstract of paper read before the National Electric Light Assoc.) (13) June 12.
The Paralleling of Alternators. (Abstract of paper read by Henry E. Longwell before the Engine Builders' Assoc.) (14) June 14.
Some Notes on Synchronizing.* Joseph Martin Roman. (27) June 14.
Works and Products of the Stanley Electric Manufacturing Company.* (27) Serial beginning June 14.
The Braun and Siemens and Halske Wireless Telegraph System. A. Frederick Collins. (27) June 14.
The Electrolysis of Gas Mains. James Swinburne, M. Inst. C. E. (66) June 17.
The Parallel Operation of Alternating Current Generators. (13) June 19.
The New Electricity Works of the Metropolitan Borough of Shoreditch.* (26) June 20.
The Edison Storage Battery. Henry F. Joel, A. M. I. C. E. (26) June 20.
The Cyclone Theory of Magnetism. Henry E. P. P. Cottrell, A. M. I. C. E. (26) Serial beginning June 27.
Salford Corporation Electricity Works and Tramways.* (26) Serial beginning June 27.
The Progress of Electric Space Telegraphy. G. Marconi. (26) Serial beginning June 27; (19) June 28.
Wireless Telegraphy. Jno. Gordon Gray. (2) July.
Electric Driving for Shops. C. A. Seley. (25) July.
The Braun-Siemens-Halske System of Wireless Telegraphy.* (19) July 5.
Electrical Plant at the Düsseldorf Exhibition.* (26) Serial beginning July 11.
Electric Power Transmission in New Zealand.* (26) Serial beginning July 11.
Advantages of Electric Transmission. F. J. A. Matthews. (47) Serial beginning July 19.
The Hoboken Station of the United Electric Company.* (14) July 19.
The Plant of the Pike's Peak Power Co.* R. M. Jones. (14) July 19.
New Power House of the Peekskill Lighting and Railroad Company.* (17) July 19.
An Electric Cement-Making Plant.* (27) July 19.
Double-Current Generators and Their Application. E. T. Ruthven-Murray. (47) July 26.
Power Transmission in the Pike's Peak Region.* (27) July 26.
Electrical Problems of Main-Line Railway Traction. Charles T. Child. (9) Aug.
Wireless Telegraphy in Meteorology. Emile Guarini. (27) Aug. 2.
Improvement in Electric Transmission by Wires. Chas. E. Fritts. (27) Aug. 2.
Installations Électrique de la Cie. Est-Lumière dans la Banlieue Est de Paris.* Henry Martin. (33) May 10.
La Production Directe de l'Énergie Électrique par le Charbon.* (33) June 14.
Note sur les Alternateurs Compound: Système Boucherot. E. J. Brunswick. (33) July 5.
Installations Électriques des Usines du Pied-Selle à Fumay (Ardennes).* C. Dufour. (33) July 12.

Marine.

Comparative Boiler Trials in Italy (Warships).* (11) May 16.
A Comparison of Five Types of Engines. W. E. Dalby. (Paper read before the Inst. of Naval Archts.) (47) May 31.
Motive Power for the Modern Launch. E. W. Roberts. (9) June.
Armour and Guns of Fighting Ships.* Philip R. Alger. (10) June.
Electricity in a Modern Shipyard.* J. B. O'Hara. (10) June.
The Bermuda Floating Dock.* (11) June 13.
The Docking of Battleships. M. Assoka. (11) June 13.
Methods of Handling Material over Shipbuilding Berths in American Shipyards. William A. Fairburn. (47) Serial beginning June 21.
The Peterson Boat-Launching Apparatus.* (19) June 28.
Report of the Committee on Naval Boilers. (11) Serial beginning July 11.
Balancing Marine Engines. W. E. Dalby. (Read before the Inst. of Naval Archts.) (11) July 11.
Coaling Plant for U. S. Navy at East Lamoine, Frenchman's Bay, Maine.* J. A. McNicol, M. Am. Soc. C. E. (13) July 24.
The *Great Eastern*.* Joseph Horner. (10) Aug.
Roulis sur Houle: Déformation et Résistance des Coques de Navires Soumises à des Efforts Statiques et des Actions Dynamiques. (36) Serial beginning May 25.

Mechanical.

Automobiles.* Harry Percy Maxim. (58) Apr.
Core Drilling with the Davis Calyx Drill.* L. V. Emanuel. (6) Apr.

* Illustrated.

Mechanical—Continued.

Liquid Fuel—Its Application, Past and Present. R. G. Paddock. (1) Apr.
Welsbach Self-Intensifying Lamps.* (66) Apr. 29.
The Construction and Inspection of Steam Boilers; with Especial Reference to the *City of Trenton* Disaster.* (3) May.
The Heating Effect of Coal. W. R. Crane. (45) May.
Mechanical Speed Changing Devices. Driving Machine Tools from Constant Speed Motors. (58) May.
Protection of Lift-Shafts and Safety Devices in Connection with Lift Doors and Controlling Gear.* (21) May.
The Renold Silent Chain Gear.* J. O. Nixon. (3) May.
Thwaite-Gardner Blowing Engine Operated by Furnace Gas at Clay Cross.* (22) May 2.
Messrs. David Rowan and Co.'s Works, Glasgow.* (11) May 9.
The Manufacture of Coke from Compressed Fuel.* John H. Darby. (22) May 9; (11) May 23.
The Recovery of By-Products in Coke-Making. J. Thiry. (22) May 9.
A New High-Duty Pumping Engine of the Compensating Type.* (14) May 10.
Ignition and Ignition Gears for Internal-Combustion Engines. Holberry Mensforth, A. M. Inst. Mech. Engrs. (47) May 10.
The Relative Advantages of Cast Iron and Wrought Iron Gas Mains. Godfrey L. Cabot. (24) May 12.
Standardization of Pipe Flanges and Flanged Fittings. Robert E. Atkinson. (62) Serial beginning May 15.
The Mechanical Plant of the Frick Building, Pittsburg.* (14) May 17.
The Introduction of the Steam Turbine for Light and Power Work.* Frank C. Perkins. (46) May 17.
Petroleum as a Fuel. Thos. Paxton. (18) May 17.
From Old Conditions to New at the Walsall Gas-Works.* (66) Serial beginning May 20.
Recent Developments in the Gas-Engine. T. Hudson Beare, M. Inst. C. E. (11) Serial beginning May 23; (47) Serial beginning June 7.
The Diamond in Wire Drawing. S. Barnett. (20) May 29.
On the Determination of the Irregularity Factor of Engines. Rudolf Franke. (Read before the Verband deutscher Elektrotechniker.) (26) Serial beginning May 30.
The German Niles Tool Works, Berlin.* (11) Serial beginning May 30.
The New Diesel Engine.* (12) Serial beginning May 30.
The Giant Crane of Bremerhaven.* (19) May 31.
Steam Engine Packing.* A. McSwiney. (Paper read before Birmingham Assoc. of Mech. Engrs.) (47) May. 31.
The Use of Alcohol in Germany for Heat, Light and Power.* Frank H. Mason. (10) June.
Mechanical Draft.* F. R. Still. (4) June.
The Battle of the Boilers. Benjamin Taylor. (64) June.
Retort-Houses for Inclined-Retort Settings and Their Development.* Edward Drory. (66) June 3.
The Condensation of Coal Gas. Harold G. Colman. (66) June 3.
The Flying Shear.* V. E. Edwards. (Paper presented to Meeting of the Am. Soc. of Mech. Engrs.) (20) June 5; (13) June 5.
Power Plant of the Schwarzschild & Sulzberger Company, Chicago.* (14) June 7.
Recovery of Bye-Products in Coke Making.* J. Thiry. (Paper read before the Iron and Steel Inst.) (66) June 10.
Determining Temperature of Exhaust Gases. R. H. Fernald. (Presented at Boston Meeting of Am. Soc. Mech. Engrs.) (62) June 12.
The Utilization of Peat as Fuel.* (13) June 12.
Cold Working Sheet Metal in Dies.* J. D. Riggs, Jun. Am. Soc. M. E. (Abstract of paper presented at Meeting of Am. Soc. Mech. Engrs.) (13) June 12.
The Hydraulic Air Compressor at Norwich, Conn.* Herbert M. Knight. (13) June 12.
Elevator Safeties.* Charles R. Pratt, M. Am. Soc. M. E. (Abstract of Paper presented at Meeting of the Am. Soc. Mech. Engrs.) (13) June 12; (14) June 14.
Detroit Steel Car Works of the American Car & Foundry Company.* (15) June 13.
Pneumatic Pumping Appliances.* W. C. Popplewell, Assoc. M. Inst. C. E. (47) Serial beginning June 14.
Piping Materials for Steam Plants. (Paper read before the Engine Builders' Assoc. by John R. Berryman.) (14) June 14.
The Steam Turbine as Applied to Blowing and Exhausting Apparatus.* W. D. Child. (66) June 17.
The Parallel Operation of Alternating Current Generators. (13) June 19.
The Fuel Briquetting Industry in the United States. Wm. G. Irwin. (20) June 19.
A Simple Form of Fuel Calorimeter. Charles R. Darling. (11) June 20.
The Manufacture of Tin-Plate. W. H. Tregoning. (22) June 20.
New Tool Steels and Their Advantages. (22) June 20.
Carbureters.* (19) June 21.
The Power Plant at the Elizabethport Shops of the Central Railroad of New Jersey.* (14) June 21.
Liquid Fuel and Its Application. R. G. Paddock. (47) Serial beginning June 21.
Large Gas-Engines and the Gases Used by Them.* Dugald Clerk, M. Inst. C. E. (Read at Meeting of the Gas Institute.) (66) June 24.
A New System of Gas Measurement. T. G. Marsh. (Read at Meeting of the Gas Institute.) (66) June 24.

* Illustrated.

Mechanical—Continued.

Efficiency and Economy in Gas Distribution.* Walter Hole. (Read at Meeting of the Gas Institute.) (66) June 24.
American Plate Mills. (22) June 27.
Shop Drawings. (11) June 27.
On Gas-Engine Temperatures. H. E. Wimperis, A. M. Inst. E. E. (11) June 27.
The Mechanical Plant of the *Chicago Tribune* Building.* (14) June 28.
The Economy of Mechanical Stoking.* William Wallace Christie. (9) Serial beginning July.
The Steam Turbine at Hartford.* (64) July.
A Proposed Standard for Machine Screw Thread Sizes. Charles C. Tyler. (Read at Boston Meeting of the Amer. Soc. of Mech. Engrs.) (41) July; (62) July 17.
Chains and Their Manufacture.* (20) July 3.
Grinding Machines and Processes. Joseph Horner. (11) Serial beginning July 4.
Coke-Oven Charging Machines.* (22) July 4.
New Apparatus for Testing Materials in the Laboratory, Purdue University, Lafayette, Ind.* William Kendrick Hatt. (11) July 4.
The U. S. Refrigerating Plant at Manila, P. I.* (14) July 5.
A Modern Printing Works.* (47) July 5.
The Selection of Steel for Various Articles. (20) Serial beginning July 10.
The Status of Alcohol as a Power Source. Marius C. Krarup. (20) July 10.
The Bleichert Aerial Ropeways.* (22) July 11.
The Paris-Vienna Motor Car Race.* (12) Serial beginning July 11.
The Mechanical Plant in the Rogers, Peet Building, New York.* (14) July 12.
Gas Engines. C. H. Nutting. (20) July 17.
New Ore Handling Machinery.* Waldon Fawcett. (62) July 17.
Depreciation of Coal and Coke by Shipment. Steikens. (Report made to the International Navigation Cong., Düsseldorf.) (11) July 18.
The Drafting System of a British Engine Shop. (14) July 19.
Scientific Tests of Alcohol Motors. M. C. Krarup. (20) July 24.
Pipes and Accessories Used in the Transmission of Power by Compressed Air. W. C. Popplewell. (47) Serial beginning July 26.
Notes on the Industrial Use of Gas Works Coke.* Alexandre Lencauchez. (24) July 28.
The Selection and Installation of Hydraulic Elevators.* Henry D. James. (13) July 31.
Producer Gas; Its Use in Engineering and Shipbuilding. F. J. Rowan. (10) Aug.
Test of a De Laval Steam Turbine Using Superheated Steam. (14) Aug. 2.
Les Conditions de Régularité des Machines de Stations Centrales. Alfred Van Der Stegen. (31) Pt. I.
Procédés et Appareils de Nettoyage des Chaudières Tubulaires.* (37) Apr.
Gazogène à Combustion Renversée par Aspiration.* J. Deschamps. (33) Apr. 26.
Étude Générale du Rendement des Nouvelles Turbines de Laval.* M. Delaporte. (37) Serial beginning May.
Théorie des Éjecto-Condenseurs et Expériences sur un Nouveau Type des ces Appareils. A. Rateau. (37) June.
Concours et Exposition de Moteurs et Appareils Utilisant l'Alcool Dénaturé.* G. Coupan. (33) June 21.

Metallurgical.

A Review on Alloys. Gustav Thurnauer. (61) Apr. 18.
The Elimination of Silicon in the Acid Open-Hearth. Andrew McWilliam and William H. Hatfield. (22) May 9; (47) May 24.
A New System of Cooling Tuyeres for Blast-Furnaces. Horace Allen. (22) May 9.
The Combined Blast-Furnace and Open-Hearth Furnace.* P. Eyermann. (22) May 9; (47) May 24.
The Chemical and Physical Properties of Carbon in the Hearth of the Blast Furnace W. J. Foster. (22) May 9.
The Influence of Chemical Composition on Soundness of Steel Ingots.* Axel Wahlberg. (22) May 9.
A Useful Alloy of Copper, Nickel, Zinc and Aluminium for Sand Casting. Erwin S. Sperry. (47) May 17.
Recent Blast-Furnace Practice.* Brierley Denham Healey. (47) Serial beginning May 17.
Puddled Iron and Mechanical Means for Its Production.* James P. Roe. (20) May 29; (16) May 31.
Handling Ore at a Blast-Furnace: Some Details of a Typical American Plant.* W. L. Cowles. (10) June.
The Chase Roasting Furnace* (16) June 7.
The Oil-Tempering of Mild-Steel Forgings. Thomas Bunt. (Paper read before the Shanghai Soc. of Engrs. and Archts.) (11) June 13.
The Metallurgy of the Cupola. H. E. Field. (20) June 19; (62) June 19.
The Molding Machine.* S. H. Stupakoff. (Read before the American Foundrymen's Assoc.) (20) June 19; (62) June 19.
Cores and Core Arbors.* Edward B. Gilmour. (62) June 19; (20) June 26.
Changes in the Manufacture of Pig Iron, as Illustrated by the Development of the American Blast Furnace.* John Birkinbine. (2) July.
Modern Developments in the Production of Open-Hearth Steel. James Christie. (2) July.

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Metallurgical—Continued.

The Steel Trade in the North-East of England.* Henry Simpson. (10) July.
Canada as a Steel Producer: The Operations of the Dominion Iron & Steel Company.* (10) July.
Bessemerising of Copper and Copper Mattes. James Douglas. (10) July.
The Economic Production of Iron and Steel: Influence of Labor-Saving Machinery in the United States.* Theodore W. Robinson. (10) July.
Upon the Structure of Metals and Binary Alloys.* William Campbell. (3) July.
The Dry Crushing of Ore. (16) Serial beginning July 5.
Hot Metal Mixers.* (22) July 18.
Notes on the Republic District, Washington, with Special Reference to the Metallurgy of its Ores.* J. C. Ralston. (16) July 19.
Nickel-Steel; Its Practical Development in the United States.* H. F. J. Porter. (10) Aug.
La Constitution des Alliages. Léon Guillet. (33) Serial beginning June 28.

Military.

The Evolution of Smokeless Powder and other High Explosives. (11) May 9.
The New 15-Pounder Quick-Firing Field Artillery Gun.* (12) May 16.
The Düsseldorf Exhibition: Krupp Pavilion.* (11) Serial beginning June 6.
Barbette for a Howitzer.* (19) June 14.
Trench, Parapet or "The Open."* (44) July.
Armor Plates Pierced.* (20) July 10.
Electricity in Its Application to Submarine Mines. John Stephen Sewell. (19) July 19.

Mining.

Core Drilling with the Davis Calyx Drill.* L. V. Emanuel. (6) Apr.
The Ehrenfeld Plant of the Webster Coal & Coke Co.* (45) May.
Compressed Air in Mining. T. W. Barber, M. I. C. E. (62) May 8.
Winding Plants for Great Depths.* Hans C. Behr. (22) Serial beginning May 16.
Safety Lamps and Colliery Explosions. (12) May 23.
Wire Ropes (for Mine Use). W. D. Hardie. (Abstract of Paper read before the Canadian Mining Inst.) (16) May 31.
Centrifugal Pumps for Mine Work.* W. R. Crane. (45) June.
Tapping Drowned Workings.* W. B. Wilson, Jr. (45) June.
Recent Shaft Sinking in Europe by the Freezing Method. (14) June 14.
Coal Mining in India.* Ernest Benedict, M. Inst. C. E. (10) July.
The Electric Locomotive for Mine Haulage: Present Practice and Economies.* George Gibbs. (10) July.
Compressed Air in Mining for Drilling, Hauling, Hoisting and Pumping.* Edward A. Rix. (10) July.
Coal Cutting Machinery; with Special Reference to American Practice.* Edward W. Parker. (10) July.
Copper in the United States.* J. Parke Channing. (10) July.
Gold Dredging in New Zealand.* H. E. Duncan. (10) July.
Gold Mining in the Transvaal, South Africa.* John Hays Hammond. (10) July.
Hydraulic Mining, Placer and Alluvial Mining, and Gold Dredging.* George H. Evans. (10) July.
The Transvaal Mines under the New Régime. John Hays Hammond. (9) July.
Colliery Ventilating Machinery.* C. M. Percy. (10) July.
Electricity in Mining.* William B. Clarke. (10) July.
Water Power in Mining; Its Various Applications in the United States.* A. P. Brayton. (10) July.
Mining Explosives. James Tonge, Jr. (45) July.
Compressed Air Haulage. Robert Peele. (45) July.
Description of Primary Operations and Temporary Plant Required for a Sinking Pit.* Harold T. Foster. (22) July 4.
Electrically-Driven Centrifugal Pumps in the Horcajo Mines, Spain.* (11) July 18.
Three-Phase Electric Driving Applied to Coal-Cutting. Roslyn Holiday. (22) July 18.
Different Methods of Hauling Ore at Bingham, Utah.* W. P. Hardesty. (13) July 24.
Mining at the Düsseldorf Exhibition. (12) Serial beginning July 25.
The Application of Suspended Steam-Pumps to the Sinking of Deep Shafts.* W. Price Adell. (22) July 25.
Sinking a Deep Coal Shaft at Atchison, Kansas. William R. Crane. (16) July 26.
Anthracite Coal Mining in the United States: A Sketch of the Pennsylvania Coal Fields.* John Birkinbine, M. Am. Inst. M. E. (10) Aug.
Les Principaux Gisements de Minerais de Fer du Monde. Léon Demaret. (30) Apr.

Miscellaneous.

Report on the Metric System. (19) May 10.
Extraordinary Trench Digging.* (46) June 21.
Physical and Chemical Laboratory of the J. I. Case Threshing Machine Co., Racine, Wis.* (13) July 10.
The Duties of Engineers in Enforcing Contracts. Albert J. Himes, M. Am. Soc. C. E. (13) July 17.
The History of the Institution of Civil Engineers. Charles Hawksley. (14) July 26.

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Miscellaneous—Continued.

The Metric System: A Practical View of It, and a Suggestion. E. Sherman Gould, M. Am. Soc. C. E. (10) Aug.
Voies de Communication et Moyens de Transport à Madagascar: Leur État Actuel—Leur Avenir. F. C. Taupiat-de Saint-Simeaux. (32) May.

Municipal.

Streets and Roads. James H. Macdonald. (1) Apr.
Bituminous Macadam Pavements. William H. Burns. (1) May.
Steel Wheelways for Wagon Roads. Ira O. Baker, M. Am. Soc. C. E. (13) May 8.
Some Observations upon the Binding of Sand by Stone Dust. Halbert Powers Gillette. (13) May 15.
The New Specifications for Asphalt Pavements in New York. (14) May 17.
The Selection of Materials for Macadam Roads. Logan Waller Page. (14) May 17.
Some Details of Broken-Stone Road Building.* (14) May 24.
Comparison of Brick Tests and Street Wear. (60) June.
The Reorganization of the Metropolitan Fire Brigade. (11) July 4.
The Cost of Brick and Stone Block Pavements. Halbert Powers Gillette. (13) July 24.
Automatic Street Sweepers.* Waldon Fawcett. (60) Aug.
Failure of Municipal Ownership in England. Robert P. Porter. (17) Serial beginning, Aug. 2.

Railroad.

Maximum Trains; Their Relation to Track, Motive Power and Traffic. E. E. R. Tratman. (65) Apr.
Construction of Elliptical Springs. Charles A. Lindstrom. (61) Apr. 18.
Reminiscences of Half a Century. M. N. Forney. (65) May.
Light Mountain Railways. George B. Francis. (1) May.
Burlington Route Test Car.* Max H. Wickhorst. (39) May.
Chicago Great Western Tandem Compound.* (39) May.
The Trans-Australian Railway. (12) May 2.
Interlocking Construction and Specifications. C. O. Tilton. (40) May 9.
Track Improvements on the Baltimore & Ohio.* (40) May 9.
Norfolk & Western Standard Equipment.* (40) May 9.
The Electric Elevated and Underground Road of Berlin.* (27) May 10.
Test and Dynamometer Car, Chicago, Burlington & Quincy R. R.* (13) May 15.
Automatic Block Signals on the Philadelphia and New York Divisions of the Pennsylvania Railroad.* (15) May 16.
Standard Freight Locomotives of the Columbian Government.* (15) May 16.
A Diagnosis of M. C. B. Coupler Defects, Based on Results Obtained in Service. R. D. Smith. (61) May 20.
Western Railway Club: Report of Committee on Draft Rigging in Relation to the Whole Cars. (61) May 20.
Industrial Railways.* Waldon Fawcett. (62) May 22.
The Atlantic Avenue Improvements of the Long Island R. R. in Brooklyn.* (13) May 22.
Pennsylvania Standard Consolidation Engine.* (40) May 23.
Early History of the Delaware, Lackawanna & Western Railroad and Its Locomotives.* Herbert T. Walker. (15) Serial beginning May 30.
Water-Tube Boiler for Locomotives.* (11) May 30.
Baldwin Decapod for the Santa Fé.* (40) May 30.
Crossing and Slip Switch Renewals on the Chicago & Western Indiana R. R.* (18) May 31.
Pennsylvania Division Shops of the N. Y. C. & H. R. R R.* (18) May 31.
Features of Continental Locomotive Construction.* Charles R. King. (9) June.
Oak Grove Shops of the New York Central.* (39) June.
Modern Car Design. C. A. Seley. (25) June.
Oil Fuel for Locomotives: Hoosac Tunnel, Boston & Maine Railroad. (25) June.
Atlantic Type Fast Passenger Locomotive, Pennsylvania Railroad.* (25) June.
Decapod Tandem Compound Freight Locomotive; Atchison, Topeka & Santa Fé Railway.* (25) June.
Mechanical Stokers for Locomotives.* Fred. H. Colvin. (Paper presented to Meeting of the Amer. Soc. of Mech. Engrs.) (20) June 5; (13) June 5; (18) June 14.
Recent Locomotives of the Illinois Central Railroad.* (40) June 6.
The Perfection Fuel Economizer and Smoke Consumer.* (40) June 6.
Building of American Locomotives.* (46) Serial beginning June 7.
Self-Dumping Cars in Railroad Construction.* Day Allen Willey. (46) June 7.
Notes on Some Twentieth Century Locomotives. Charles Rous-Marten. (47) Serial beginning June 7.
The Elevated Structure of the Atlantic Avenue Improvement, Brooklyn.* (14) June 7.
Electric Traction and Standard Railways. E. Huber. (17) June 7.
Staybolt Breakage.* (15) June 13.
New Engine House of the Boston & Maine at East Cambridge.* (15) June 13.
Cast-Iron Wheels Under Heavy Cars.* (15) June 13.
Some Modern Draft Gears.* (15) June 13.
The Structural Steel Car Company.* (15) June 13.

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Railroad—Continued.

Some Experience with Special Wheels in Heavy Service. P. H. Griffin. (15) June 18.
The Railroad Telephone. C. A. Hammond. (15) June 18.
New Power for the Frisco System.* (40) June 18.
The Baring Cross Shops of the St. Louis, Iron Mountain & Southern Railway.* (40) June 18; (18) Serial beginning June 14.
The Locomotive Piston Valve.* (18) June 11.
The Largest Geared Locomotive Yet Built—El Paso & Rock Island Route.* (18) June 14; (15) June 20.
The Question of Power for Railroad Repair Shops. (18) June 14.
The Electric Road of Berthoud-Thoune, Switzerland.* (46) June 14.
The New Beacon Mountain Railway.* (17) June 17.
Michigan Central Shops at Jackson, Mich.* (40) June 20.
Competitive Locomotive Types for the Illinois Central.* (15) June 20.
New Locomotive Equipment for the St. Louis & San Francisco R. R.* (18) June 21.
The Cedar Lake Shops of the Minneapolis & St. Louis R. R.* (18) June 21.
M. N. Forney's Feed Water Heater for Locomotives.* (15) June 27; (25) July; (47) July 12; (18) Aug. 2.
The Chicago & Alton Shops at Bloomington, Ill.* (15) June 27.
Two New Types of Suburban Locomotives.* (40) June 27; (15) June 20.
An Improved Fuel Economizer and Smoke Consumer.* (18) June 28.
Railway Blocks and Telegraphs—Recent Practice. (21) July.
The Effect of Waterways on Railway Transportation. S. A. Thompson. (9) July.
Steel Rails: Relations between Structure and Durability.* Robert Job. (3) Serial beginning July; (15) July 4. (13) July 3.
The Pryor Gap Tunnel; Burlington & Missouri River R. R.* F. T. Darrow. (13) July 3.
Prospective Railway Development in British Equatorial Africa. C. Steuart Betton. (29) July 4.
The Simplon Tunnel and Its Construction. (12) Serial beginning July 4.
The Construction of a First-Class French Locomotive.* (12) Serial beginning July 4.
Grand Rapids, Grand Haven & Muskegon Railway.* (17) July 5.
Train Resistance. A. H. Armstrong. (17) July 5.
Train Resistance Formulæ. John Balch Blood. (17) July 5.
Tests of the Friction of Side Bearings and Center Plates for Freight Cars: Abstract of Report of Special Committee of the Master Car Builders' Assoc.* (13) July 10.
Modern Water Supply for Locomotives.* F. M. Whyte. (15) July 11.
Electric Driving for Shops. C. A. Seley. (Paper read before the Amer. Ry. Master Mech. Assoc.) (18) July 12.
A Combination Transfer Table and Car Elevator.* (13) July 17.
Railway Grade Crossing Protection in Texas. (13) July 17.
The Superintendent, the Conductor and the Engineman. B. B. Adams. (15) July 18.
Crosshead and Piston Rod Connection.* Roger Atkinson. (15) July 18.
The Commodity Ton Mile. S. M. Hudson. (40) July 18.
Automatic Train-Order Signal, Hocking Valley Ry.* (18) July 19.
A Typical Shop to Serve for 300 Locomotives.* L. R. Pomeroy. (Read before Annual Convention of the Amer. Ry. Master Mech. Assoc.) (18) Serial beginning July 19; (25) Aug.
A Lens Mirror Locomotive Headlight.* (13) July 24.
The Perfection Fuel Economizer and Smoke Consumer.* (15) July 25.
"Boulder" Signalling and New Express Locomotives on the Caledonian Railway.* Norman D. Macdonald. (40) July 25.
The Baltimore & Ohio Third Rail System.* (40) July 25.
The Tehuantepec Railroad *vs.* the Isthmian Canal.* (46) July 26.
Consolidation Freight Locomotives for N. Y. C. & St. L. and P., C., C. & St. L. Roads.* (18) July 26.
A Large Shay-Patent Locomotive; The El Paso & Rock Island Route.* (25) Aug.
The Mexican Railway System.* Victor M. Braschi and Ezequiel Ordoñez. (10) Aug.
Up-to-date Roundhouses.* (25) Aug.
Passenger Engines for the Chesapeake & Ohio and the Missouri Pacific.* (15) Aug. 1.
A New Method of Steel Car Construction. (18) Aug. 2.
The Mechanical and Electrical Equipment of the Pittsburg & Lake Erie Railroad Terminal, Pittsburg.* (14) Serial beginning Aug. 2.
Les Tramways à Vapeur aux Indes Néerlandaises (Java, Madoura et Sumatra). Auguste Moreau. (32) Mar.
Les Chemins de Fer de l'État de Saint-Paul (Brésil).* (38) May.
Les Voitures des Chemins de Fer Italienes à l'Exposition Universelle de 1900.* A. Marizot. (34) May.
Applications de la Vapeur Surchauffée aux Locomotives.* F. Barbier. (33) May 31.
Nouvelle Ligne de Paris à Versailles: Tunnel de Mendon.* A. Dumas. (33) June 7.
Locomotives Compound à Quatre Cylindres de la Compagnie des Chemins de Fer de l'Est.* L. Pierre Guédon. (34) Serial beginning July.
Note sur les Travaux de la Ligne d'Issy à Viroflay.* M. Rabut. (38) July.
Nouvelle Locomotives Compound à Quatre Cylindres à Dispositif de Démarrage Système Goelsdorf.* L. Pierre Guédon. (33) July 12.

Railroad, Street.

Electric Traction. Philip Dawson. (26) Serial beginning May 9.
The New Electric Rapid Transit Railway in Berlin, Germany.* (13) May 15.

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Causes and Remedies for Vibration. A. Mallock. (17) May 17.
Selection of Street Railway Motor Equipment. Fred A. Jones. (17) May 17.
Express and Light Freight Traffic on Electric Roads. (15) May 23.
Restrictions on the Controller Handle. J. R. Cravath. (17) May 24.
Power Plant of the Hartford & Springfield Street Railway Co.* (14) May 24.
Construction of the Metropolitan Railway, Paris.* (14) May 24.
Camp's Bay, Cape Town and Sea Point Tramways.* (26) May 30.
Problems of Electric Railways. J. Swinburne and W. R. Cooper. (Paper read before the Inst. of Elec. Engrs.) (19) Serial beginning May 31.
The Vevey-Mont Pélerin Funicular Electric Railway.* Enrico Bignami. (9) June.
Cardiff Corporation Tramway.* (26) June 6; (17) July 5.
Electric Railway Practice on the Continent of Europe.* Heinrich Veilguth. (17) June 7.
Results of Tests for Air Resistance on the Berlin-Zossen Experimental High Speed Line.* (17) June 7 and Aug. 2.
Mineola, Hempstead and Freeport Traction Company.* (17) June 28.
The Design of Conductors for Electric Railways. (47) June 28.
The Mechanical Engineering of an Electric Railway.* Howard P. Quick. (9) July.
New Equipment of the Liverpool Overhead Railway.* (26) July 4; (17) July 19.
Collectors for Heavy Traction. George T. Hanchett. (17) July 5.
International Tramways Exhibition.* (47) July 12.
The Electric Tramway System of Newcastle-on-Tyne.* (26) Serial beginning July 18.
The Second Division of the New York Rapid Transit Railroad.* (14) Serial beginning July 19.
Recent Improvements on the Boston Elevated Railway.* (17) July 26.
Power Plant of the Berkshire Street Railway Co, Pittsfield, Mass.* (14) July 26.
The Central Power Station of the Glasgow Municipal Electric Tramways.* (64) Aug.
Power Brakes for Street Cars. (15) Aug. 1.
Peckham's High Speed Electric Railroad Trucks.* (15) Aug. 1.
Trolley Omnibus Line between Nice and Upper Monte Carlo.* (17) Aug 2.
The System of the Youngstown-Sharon Railway and Light Company.* (17) Aug. 2.
The Electric Third Rail.* W. B. Potter. (17) Aug. 2.
Description du Réseau des Tramways Électriques de Marseille.* M. Denizet. (43) 1er Trimestre.
Les Chemins de Fer Électriques. Léon Gerard. (32) Mar.
Chemin de Fer sur Route de Paris à Arpajon * G. Boëto. (33) Apr. 26.
Métropolitan d'Intéret Local de Berlin: Installations Électriques et Matériel Roulant.* Henry Martin. (33) May 17.
Conduite Souterraine à Rainure Latérale.* A. Vallee. (36) May 25.
Equipement de la Sous-Station des "London United Tramways." (36) May 25.
Chemin de Fer à Traction Électrique du Fayet à Chamonix.* Henry Martin. (33) Serial beginning June 28.
Note sur le Dépot de la Compagnie des Tramways de l'Est, Parisien aux Lilas (Seine).* G. Lelarge. (38) July.

Sanitary.

The Intermittent Sewage Filters at Pittsfield, Mass.* (14) May 10.
The Action of the Septic Tank on Acid Sewage. (14) May 10.
New System of Street Cleaning.* (46) May 10.
Electro-Pneumatic Control of the Moon Island Sewage Reservoir. (18) May 17.
Electric Sewage Pumps, Septic Tanks and Contact Beds at Fond du Lac, Wis.* Geo. S. Pierson, M. Am. Soc. C. E. (13) May 22.
Experiments at Worcester, Mass., on Treating Acid Iron Sewage in a Closed Septic Tank. Leonard P. Kinnicutt and Harrison P. Eddy (13) May 29.
The Present Status of the Sewage Problem in England.* Leonard P. Kinnicutt. (1) June.
The Purification of Sewage. (Paper read before the Illinois Society of Civ. Engrs. and Surveyors). (60) June.
Heating a New York Residence.* (14) June 14.
The Mitchell System of Sewage Disposal. (14) June 14.
The Sanitary Measures to be Adopted after Floods. George A. Soper. (19) June 14.
Sewage Purification Works at Depew, N. Y.* G. Everett Hill. (13) June 26.
House Drainage. A. B. Raymond. (Paper read before the Michigan Eng. Soc.) (60) July.
Water Supply in the Carnegie Residence, New York.* (14) July 5.
The Drainage of New Orleans. (11) July 25.
Concrete Sewer Construction at the Chicago Clearing Yards (14) Aug. 2.
Plumbing in the Carnegie Residence, New York.* (14) Aug. 2.
L'Épuration des Eaux d'Égouts en Belgique par la Méthode Chimicobiologique. Duyk. (30) Apr.

Structural.

A New Method of Testing Fire-Resisting Qualities of Fireproofed Wood.* Ira H. Woolson, M. Am. Soc. M. E. (6) Apr.
On the Burning of Portland Cement. Wm. B. Newberry. (67) May.
The Determination of Unit Stresses in the General Case of Flexure. L. J. Johnson. (1) May.

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Structural—Continued.

Underpinning the Decker Building, New York.* (14) May 10.
Theory of the Strength of Beams of Reinforced Concrete. W. Kendrick Hatt. (Abstract of Paper read before the Indiana Eng. Soc.) (14) May 10.
The New York Stock Exchange Building.* (14) May 17 and May 24.
Fire Tests of Fireproof Floors by the New York Building Department.* (13) May 29.
A Visit to the Plant of the Edison Portland Cement Co. at Stewartsville, N. J. (13) May 29.
A Steel and Concrete Coal Storage Plant.* Franklin M. Bowman. (Abstract of Paper presented at the Convention of the Am. Soc. M. E.) (14) May 31.
The Twenty-Third Street Y. M. C. A. Building, New York.* (14) May 31.
The Designing of an Office Building.* Colbert A. MacClure. (58) June.
The Fire-Proofing of High Office Buildings. Peter B. Wight. (58) June.
The Building Laws of the City of Pittsburg. J. A. A. Brown. (58) June.
Monier Cement Storage Elevator at South Chicago.* (67) June.
Wet, Dry or Medium Concrete. H. W. Parkhurst. (4) June.
Practical Strength of Columns or Struts of Wrought Iron and Mild Steel.* J. M. Moncrieff, M. Inst. C. E. (11) June 6.
Acoustics of Audience Halls. C. H. Blackall. (Reprinted from the *Technograph.*) (14) June 7.
Extension of the Corn Exchange Bank Building, New York.* (14) June 14.
The Pneumatic Foundations of the Battery Place Building, New York.* (14) June 21.
The North German Lloyd Pier-Sheds, Hoboken.* (14) Serial beginning June 21.
The Permeability of Concrete under High Water Pressures. J. B. McIntyre and A. L. True. (13) June 26.
The New Pittsburg Plant of the American Bridge Co., near Economy, Pa.* (13) June 26.
Anti-Corrosive Paints; Their Qualities and Composition. (11) June 27.
Tests of Reinforced Concrete Beams. W. Kendrick Hatt. (Paper read before Amer. Section, International Assoc. for Testing Materials.) (14) June 28.
The Cement Testing Laboratory at Cornell University.* Edgar B. Kay. (60) July.
Various Recipes for Cements, Mortars, etc. (67) July.
Portland Cement; Its Constitution, Properties and Manufacture. Richard K. Meade. (3) July.
Portland Cement: Description of Methods Employed in Its Manufacture and Types of American and Foreign Cement Machinery. Richard K. Meade. (45) July.
Underpinning a Tall and Narrow Brick Building.* (14) July 5.
Standard Cement Specifications. R. W Lesley, Assoc. Am. Soc. C. E. (Paper read before the Amer. Section, International Assoc. for Testing Materials.) (14) July 5.
Cement Testing in Municipal Laboratories. R. L. Humphrey. (Paper read before the Amer. Section, International Assoc. for Testing Materials.) (14) July 12.
Notes in Experience in Masonry Construction. F. A. Mahan. (13) July 17.
The Manufacture of Cement from Slag: The Curtin Process.* (20) July 17.
The Battery Place Building, New York.* (14) July 19.
Some Recent Experiments with Cements, Mortar and Concrete. Thomas S. Clark. (13) July 24.
Diagrams for Determining the Weight of Steel Trusses and Plate Girders. H. G. Tyrrell. (11) July 25.
Raymond Concrete Piles.* (18) July 26.
Accuracy and Value in the Testing of Cast Iron. Richard Moldenke. (9) Aug.
Test of a Concrete Slab Reinforced with Expanded Metal.* O. W. Connet. (14) Aug 2.
Expériences sur le Ciment Armé. M. Breuillé. (43) 1er Trimestre.
Note sur les Constructions en Ciment Armé. Boussiron. (36) Serial beginning May 10
Les Bétons de Ciment Armés. M. Dumas. (30) June.
Méthode de M. Brinell pour la Détermination de la Dureté des Corps par l'Enforcement d'une Bille d'Acier dans la Substance Étudiée. (36) June 10.
Fabrication du Portland Artificiel par Fours Portatifs. E. Leduc. (36) July 10.

Topographical.

A Labor-Saving Tool for the Drafting Room.* (13) May 15.
The Arid District between the Rio Grande and the Pacific Traversed by the Engineers of the Mexican Boundary Commission in 1892-94. Oscar C. S. Carter. (2) July.
New Types of Hand Surveying Instruments.* (11) July 11.
Surveying in Central America. (14) July 19.
Ferguson's Surveying Circle and Percentage Unit of Angular Measurement John C. Ferguson, M. Inst. C. E. (11) July 25.

Water Supply.

Filtration of River Water. Alfred J. Jenkins, Assoc. M. Inst. C. E. (66) Apr. 29.
The Iron Coagulant Process at Lorain. (14) May 10
The Kennicott Water Softening System.* (13) May 15.
The Utility of Subsiding Basins. (14) May 17.
Concrete Lined Reservoir with Concave Slopes at Aurora, Ill. (13) May 22.
Recent Developments in Punjab Irrigation. Sydney Preston. (29) May 30.
The Purification of Feed Water.* (19) May 31.

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Preliminary Report of the Committee on Standard Specifications for Cast-Iron Pipe, with Discussion. Freeman C. Coffin, F. F. Forbes and Dexter Brackett. (28) June.
The Marlborough Water-Works.* George A. Stacy. (28) June.
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* Illustrated.

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AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

THE FLOW OF WATER IN WOOD PIPES.

By Theron A. Noble, M. Am. Soc. C. E.

To be Presented October 1st, 1902.

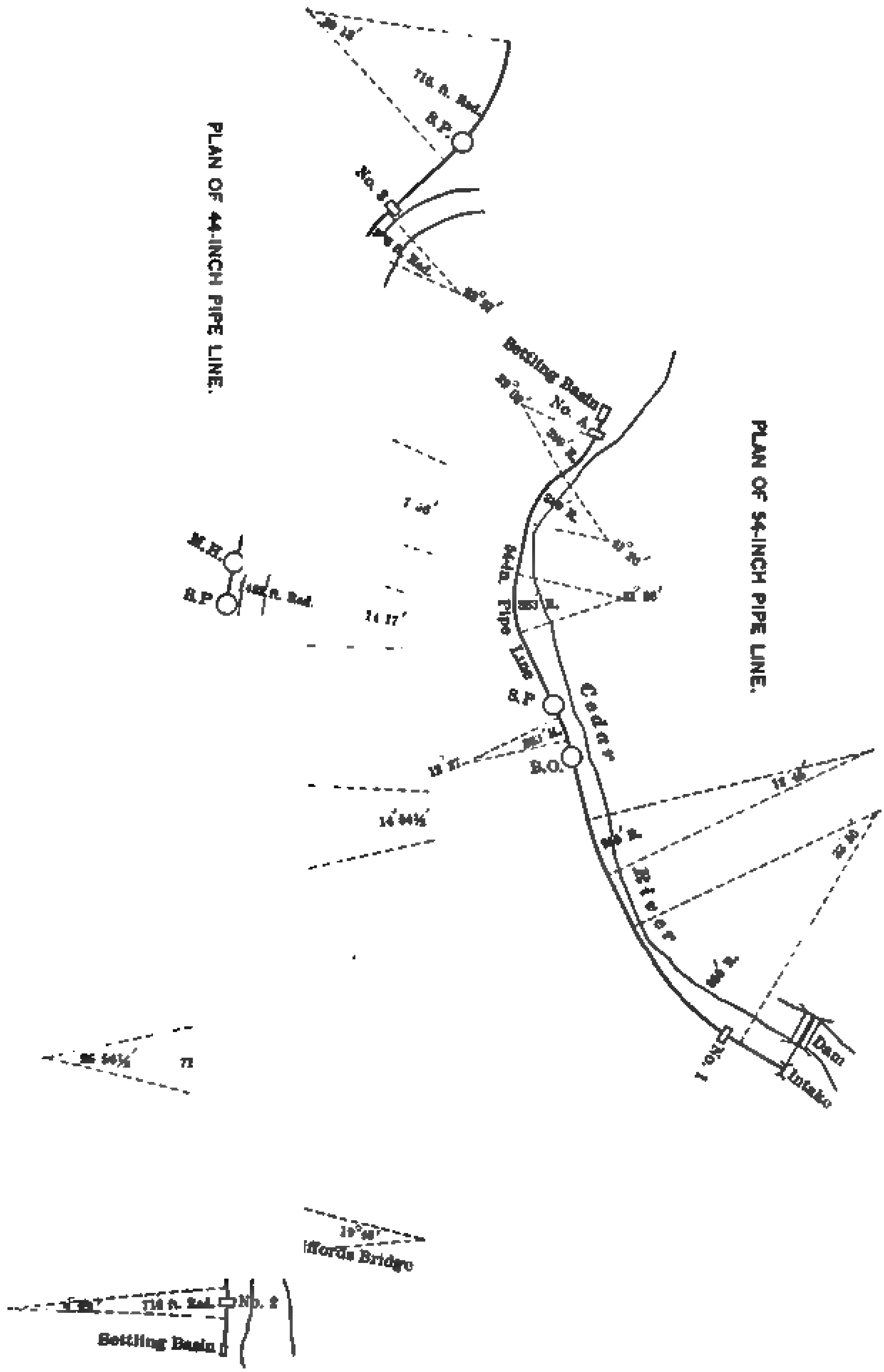
Before entering into a discussion of the series of experiments conducted by the writer, through the courtesy and assistance of Reginald H. Thomson, C. E., City Engineer of Seattle, Wash., a brief description of Seattle's gravity supply will be required, in order to fully understand the conditions under which the experiments were conducted.

Description of Gravity System.—About 24 miles southeast of Seattle, as the crow flies, the city has constructed, across Cedar River, a dam which diverts the water for the city's domestic water supply into a series of pipe lines 28.52 miles in length, connecting the dam directly with the high-service reservoir in the city. These lines consist of 54-in., 44-in. and 42-in. stave-pipe, and 42-in. steel pipe.

The first section consists of 2 679 ft. of 54-in. stave-pipe extending from the intake at the dam to the settling basin. The plan and profile of this section are shown in Figs. 1 and 3.

The dam and the upper part of the 54-in. pipe line are shown in Figs. 1 and 2, Plate XXIII.

Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited, from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers with discussion in full will be published in *Transactions*.



PLAN OF 44-INCH PIPE LINE.

PLAN OF 54-INCH PIPE LINE.

FIGS. 1 AND 2.

At the intake, the water is controlled by a large sluice-gate, operated in the usual manner, with racks, pinions and handwheel.

At the settling basin, Fig. 4, the pipe enters a well where the water is either diverted into a 24-in. by-pass, by shutting down a large wooden sluice-gate, or allowed to flow through the basin. The opening between this well and the basin is 5 ft. in diameter, and is built in the concrete wall dividing the well from the basin.

The water entering the settling basin passes through two sets of screens extending across the basin and through a 48-in. sluice-gate into the 44-in. pipe, the first of a series of 44 and 42-in. wood and steel pipes leading direct to the high-service reservoir in the city.

There are only two connections with this line; one 24-in. connection leading to Beacon Hill Reservoir (which was the reservoir used in connection with the old pumping system), and one 36-in. connection leading to the low-service reservoir. Neither of these connections is in use at the present time.

The settling basin is 80 ft. long (including the well), 25 ft. wide and 18 ft. deep. It is in-

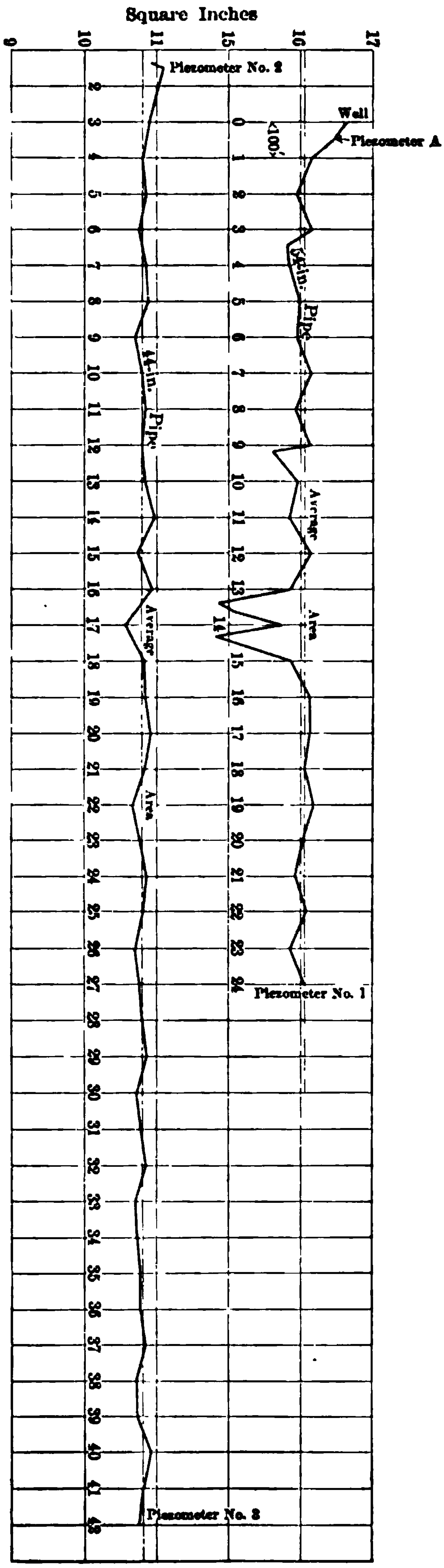


FIG. 8.

FIG. 1.—DAM AND INTAKE, SEATTLE WATER-WORKS.

FIG. 2.—UPPER PART OF 54-IN. PIPE, SEATTLE WATER-WORKS.

tended for separating any foreign matter which may pass through the racks at the intake, and is arranged with a by-pass, so that it is not necessary to shut down the line while the basin and screens are being cleaned. It is drained through three 24-in. sluice-gates, which discharge into three cast-iron pipes connecting with a common drain tunnel. There is also a 3-in. valve connecting with the 24-in. by-pass, and a drain tile connecting with a subsoil drain surrounding

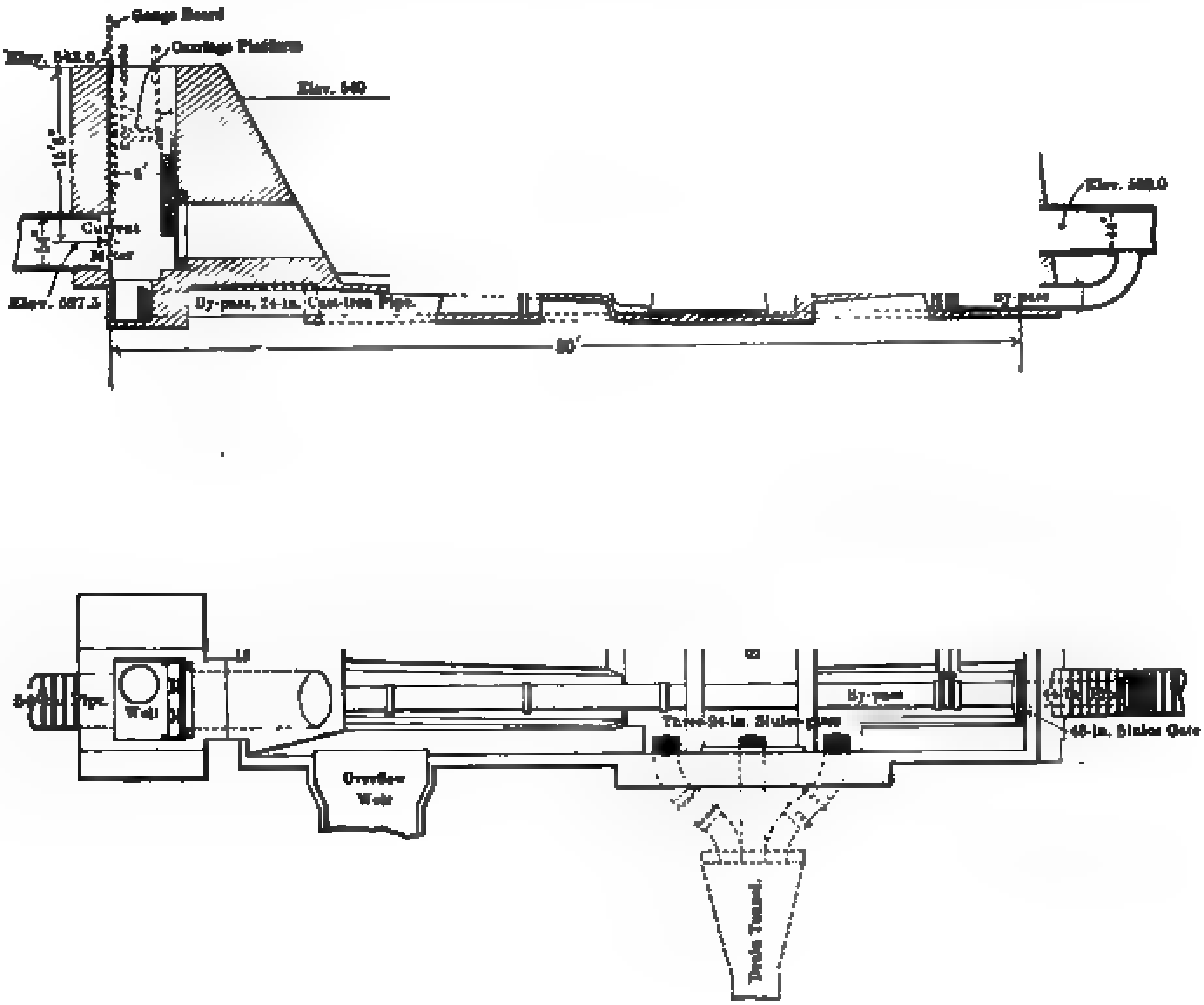


FIG. 4.

the foundation, which also drains into this tunnel. The quantity of water coming from this drain tile and from the 3-in. valve was so small that the proportion coming from outside the basin, through the drain tile, has not been taken into account. The drain tunnel is rectangular in section, with an arched roof built of concrete, 3 ft. wide and 5 ft. high inside. During these experiments it was impossible to prevent leakage through these drain valves. The quantity

was measured with a weir at the mouth of the drain tunnel, and allowed for. From the settling basin the water passes into the following pipes consecutively:

71 262 ft.	of	44-in. stave-pipe;
5 405	"	42-in. stave-pipe;
8 982	"	42-in. steel pipe across Black River Valley, where the maximum pressure is about 470 ft.;
13 503	"	42-in. stave pipe;
16 545	"	42-in. steel pipe, crossing Dunlap's Cañon;
18 163	"	42-in. stave pipe;
6 385	"	42-in. steel pipe crossing a low divide in the hill above the city;
7 687	"	42-in. stave pipe to the high-service reservoir.

Making in all:

1 section	of	2 679 ft.	of	54-in.	stave pipe.
1 "	"	71 262	"	44-in.	"
4 sections	"	44 758	"	42-in.	"
3 "	"	31 912	"	42-in.	steel pipe.

Total.... 150 611 ft., or 28.52 miles.

The following are the principal elevations:

Crest of dam	536	ft.
Crest of weir at high-service reservoir	421.33	"
Total friction head	114.67	ft.
Average per 1 000 ft	0.761	"

It had been the intention, originally, to take such measurements as would make it possible to determine the loss of head in each of the different kinds of pipe, but, owing to the impossibility of measuring the discharge at any point in the line except at the head works, and the fact that there was considerable leakage at several points along the line, the writer concluded to confine his experiments to the two sizes of pipes near the head works, viz., the 54-in. pipe leading from the dam to the settling basin, and the 44-in. pipe leading out of the settling basin for a distance of about 4 200 ft. These two lengths being nearest the point of measurement, and under comparatively light pressure, there would be less danger of leakage, and it was possible to measure the loss of head with open piezometer tubes.

Fig. 1.—Piezometer No. 1.

Fig. 2.—Piezometer No. 2.

Fig. 3.—Piezometer No. 3.

Location of Piezometers.—The question of the proper location of the connections with the piezometer tubes involved a study of the probable conditions affecting the results of the experiments.

It was desirable, in the first place, to make the distance between piezometers as great as possible, in order to reduce to a minimum errors in piezometer heights from various causes. It was of importance to locate the lower piezometer on the 44-in. pipe so that the widest range of hydraulic grade could be obtained. It was also desirable to locate the piezometers where the pipe was of uniform section, and nearest the average diameter. This, however, was a blind guess, as it was impossible to make an examination of the inside of the pipes at that time. The writer was fortunate in this respect, as, by an examination made two months later, it was found that the piezometers could not have been placed to much better advantage.

Piezometer No. 1, the upper one on the 54-in. pipe, was located 232 ft. from the intake. (See Figs. 1 and 3. and Plate XXIV, Fig. 1.)

The lower piezometer heights, for the 44-in. pipe, were taken in the well with a hook-gauge, Fig. 5. This well is 5 x 7 ft. and 19 ft. deep inside. The measurements for flow were taken with a current meter, from a platform suspended in the well at the opening from the pipe.

HOOK GAUGE.

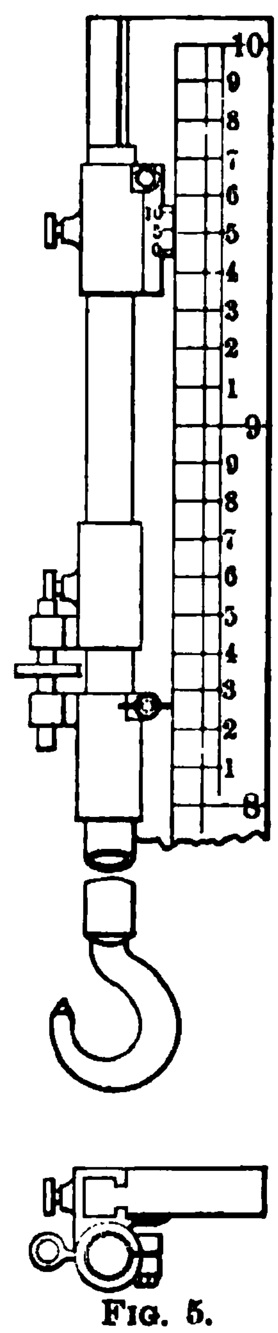


FIG. 5.

After taking the first series of observations on the 54-in. pipe (from 1 to 11, inclusive), the writer had some suspicion that the hook-gauge reading did not give the true piezometer height, and decided to attach a piezometer some distance back of the well and take two observations, one at the lowest and one at the highest hydraulic gradient used in the experiments. This piezometer (Piezometer A, see Figs. 1 and 3) was located 47.5 ft. from the inside face of the well.

The hook-gauge was made with brass fittings, the rod being a seamless drawn-brass tube. The hook was of steel, with the point hardened. The gauge was fastened to the well curb. The hook extended into a wooden box which protected the surface of the water from the fluctuations prevailing in the well. As the temperature during the experiments did not vary more than 10°, the changes in the length of the rod were not sufficient to be taken into account.

Piezometer No. 2 was located on the 44-in. pipe, 150.6 ft. down stream from the inside wall of the basin. (See Figs. 2 and 3, and Plate XXIV, Fig. 2.)

Piezometer No. 3 was located on the 44-in. pipe, 4 041 ft. down stream from Piezometer No. 2, on the crest of the bank above the river valley. (See Figs. 2 and 3, and Plate XXIV, Fig. 3.)

Description of Piezometers.—To determine what resistance, if any, there was in the fittings, in the lengths of pipe experimented upon,

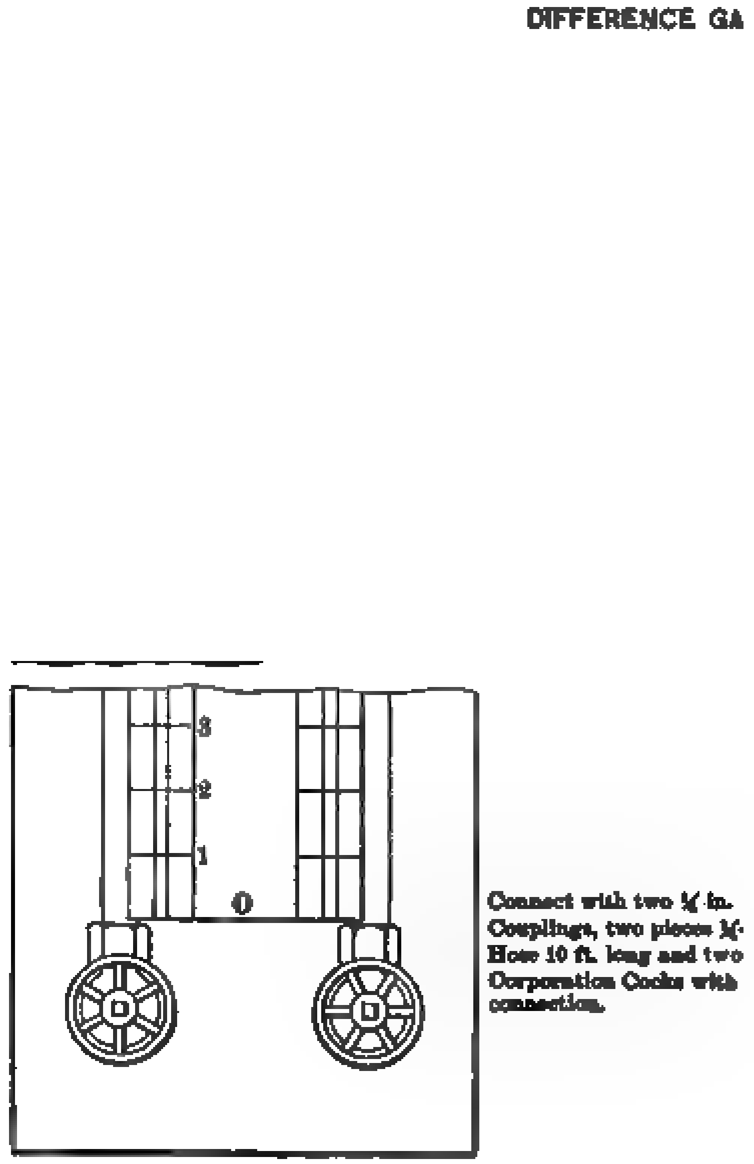


FIG. 6.

an oil differential gauge, Fig. 6, had been constructed to determine very slight differences of pressure. One side of this gauge was detached, and the glass tube and fittings were attached to another board with a separate scale. As only two piezometers were required at any one time, these two tubes answered for all purposes. The glasses were ⅝ in. outside diameter, 5 ft. long in the clear, mounted in com-

FIG. 1.—BLOCK, SHOWING HOLE BORED FOR ATTACHMENT OF PIEZOMETERS.

FIG. 2.—BLOCK, SHOWING HOLE BORED FOR ATTACHMENT OF PIEZOMETERS.

mon, boiler-gauge fittings, on a $1\frac{1}{4}$-in. board. Each lower fitting was connected with 10 ft. of $\frac{1}{2}$-in. hose. The hose was connected to a $\frac{1}{2}$-in. corporation cock screwed into a suitable hole bored into the wood pipe.

Attachment of Piezometers.—Instead of boring the hole (for inserting the corporation cock) completely through the pipe, and thus making a sharp and splintered edge, the bit was withdrawn as soon as the screw had passed through into the interior of the pipe. This left a clean hole, about $\frac{3}{16}$ in. in diameter, entirely free from any internal projection. (See Plate XXV, Figs. 1 and 2.) These holes were afterward examined on the inside of the pipe, and found to be free from any projection.

All holes were bored with a gauge which kept the bit perpendicular to the outer surface of the pipe.

Levels of Piezometers.—As it was not possible to shut down the gravity system, except from the head works, it was impossible to ascertain the static head at the several piezometers, except by leveling.

To determine the heights of zero on each piezometer scale, levels were run by three different observers, and the average of the two which agreed most nearly was taken as correct. The greatest difference between any two observers was 0.015 ft. The probable error is not over 0.007 ft. The least hydraulic gradient experimented upon was 0.342 ft., so that the greatest possible error from this cause was about 2 per cent.

Measurement of Flow.—There was no choice as to the method to be used for measuring the discharge. No provision for metering the water was made when the system was planned, except a sharp-crested weir which had been provided in the gate-house of the high-service reservoir at the discharge end of the line.

In any case, this weir would not answer for measuring the discharge at the intake end of the line, where it was necessary to carry on the experiments in order to get as wide a range of friction head as possible, as the quantity of leakage in the long length of pipe was an uncertain factor.

The measurements for discharge were made with Haskell's current meter *C*, having a $7\frac{1}{2}$-in. wheel, with the ordinary holding rod 15 ft. long, and the regular electrical connections, provided with a telegraph sounder. Fig. 4 shows the well. The general arrangements for holding the meter in position are shown in dotted lines.

A platform was hung in the well just above high-water level, leaving, next to the wall, an open space containing the pipe opening, about 1 ft. wide. On this platform was laid a track of two angle irons planed on their upper edges. This track was carefully leveled, and laid parallel to the face of the wall and perpendicular to the axis of the pipe. For the track, a carriage was constructed to which was attached a framework to hold the meter rod in position and allow the desired vertical and horizontal movements of the meter—the horizontal movement being obtained from the motion of the carriage on the track, and the vertical motion from the movement of the meter rod in a vertical groove in the front of the frame.

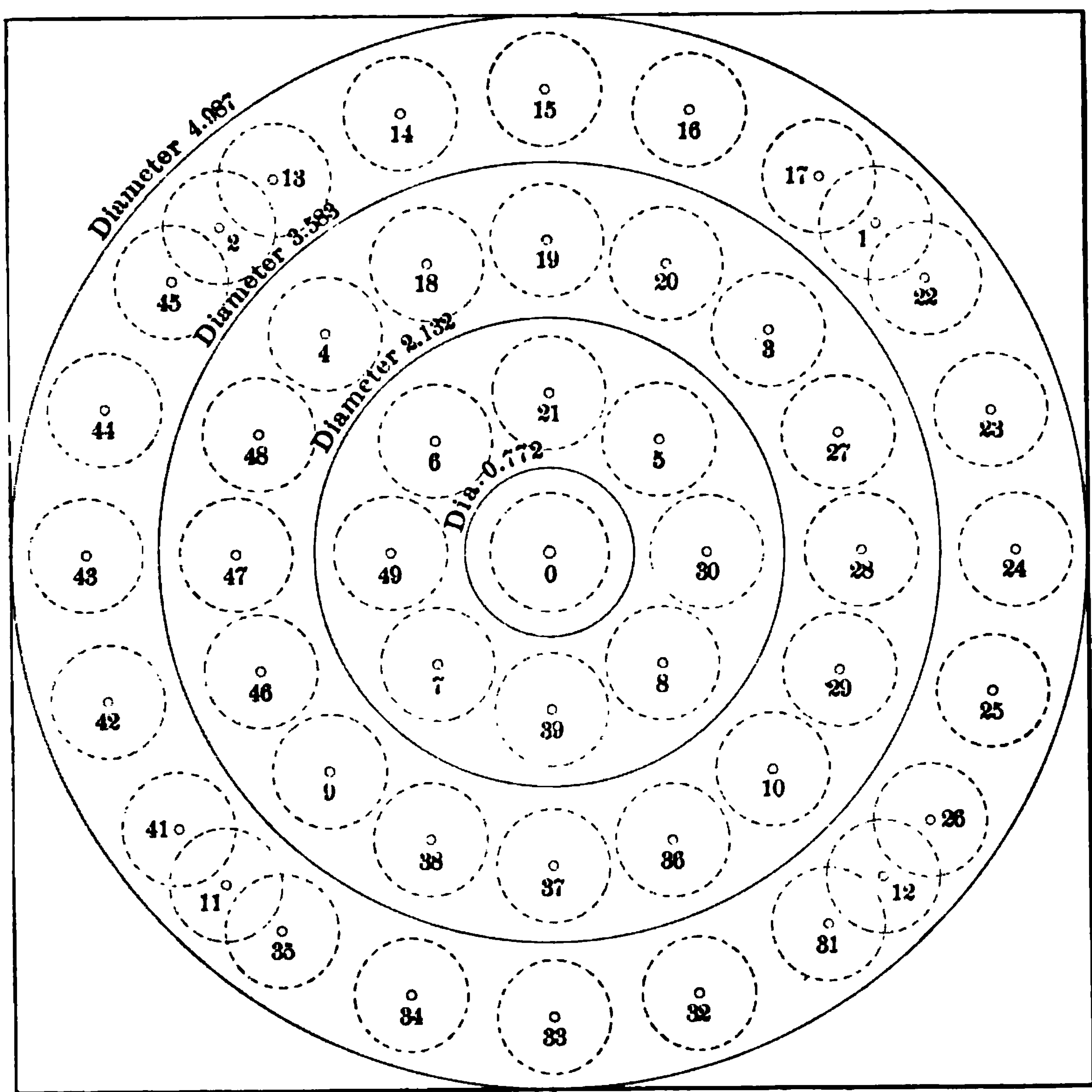
It was found that the carriage could not be made sufficiently small to give the amount of travel necessary to get the two extreme velocity readings of the horizontal diameter of the opening, thus covering only 47 out of 49 readings for the whole area of the opening. To the top of the meter rod was clamped a block of wood, 6 ins. wide and 18 ins. long, near the top of which was a hole for inserting a pin used to hold the meter and carriage in position on the board, while taking each velocity reading. The front face of this block was placed on the meter rod exactly at right angles to the axis of the meter wheel, so that, when held in position against the guide board, the axis of the wheel would be parallel to the axis of the pipe.

The guide board, Fig. 7, was made of 1-in. D. and M. flooring, 5 ft. square, braced on the back and fastened to the curb of the well in such a position that, when the wheel was in the center of the opening, the pin in the top of the block would be approximately in the center of the board. A blank wheel, 1 in. larger in diameter than the meter wheel, was then put on the spindle of the meter, and the meter, with the rod, etc., was put into place. The blank wheel was then brought up against the inside surface of the opening at various points on its circumference, and the corresponding points on the board were plotted from the hole in the block. Through these points a circle was drawn, which was the line for the outer set of holes to be used in locating the meter for the velocity readings.

From this circle, the outside circumference of the pipe, as projected on the board, was located, and the center and four diameters were drawn. This projected area of the opening was then divided into four concentric rings (including the center), and a circle was

drawn in the center of each ring; the holes for the velocity readings being all spaced on these circles, the velocity readings would be taken in the center of each ring. The average of the velocity readings inside of each ring was calculated separately and multiplied by the area of the corresponding ring, to determine its discharge, the sum of the discharges of the separate rings making the total discharge through the opening.

GUIDE BOARD



5 feet

5 feet

FIG. 7.

The spacing of these holes on the circles was first made on four diameters, and the intervening spaces between the diameters were filled in at regular intervals, making in all 47 holes, not counting the two holes at the ends of the horizontal diameter, which could not be used.

The area of the opening is 19.533 sq. ft., which is not the same as the area of the end of the pipe (16.605 sq. ft.), as the pipe does not extend to the well, within 8 ins., but is the same as the outside area of the pipe.

Before everything was in working order, it was found that some part of the frame or platform had sprung sufficiently to misplace the meter about 1 in., so that when the pin was placed in the outer holes on the left side of the guide board, the meter would foul, making it necessary to bore several new holes on this side nearer the center of the circle. This misplaced all other holes 1 in. It was assumed that this would not affect seriously the general average of the discharge measurements; it was, in fact, an advantage to have the velocity readings taken closer to the left of the opening, as the velocity was higher on this side on account of a curve to the right about 50 ft. back of the well.

The current meter was rated both before and after the experiments. The rating before the experiments was not very satisfactory, on account of surface currents. The second rating was made under more favorable conditions, and the boat was run twice in opposite directions over the same course at each velocity.

Two minutes were occupied in each velocity reading at the well: One minute for counting the sounder and one for changing the position of the meter rod to the next hole.

In order to determine whether it would be necessary to take readings from all the holes on the guide board, an observation was taken first at the lowest velocity, with a reading at every hole on the guide board (with the exception of the two at the extremities of the horizontal diameter). The order of taking readings was as follows: 1, 3, 5, 0, 7, 9, 11; 2, 4, 6, 0, 8, 10, 12; 15, 19, 21, 0, 39, 37, 33; 47, 49, 0, 30, 28; 13, 14, 18, 16, 17, 20, 22, 23, 27, 25, 26, 29, 31, 32, 36, 34, 35, 38, 46, 41, 42, 45, 44, 48.

This order of taking readings was maintained in all subsequent observations.

The discharge at the opening from all, or 50, readings was........................ 36.529 cu. ft. per second.
From two diameters, or 14 readings (1, 3, 5, 0, 7, 9, 11; 2, 4, 6, 0, 8, 10, 12), was..... 36.621 " "
From one diameter, or 7 readings (1, 3, 5, 0, 7, 9, 11), was......................... 36.614 " "

From one diameter, or 7 readings (2, 4, 6, 0,
8, 10, 12), was .... 36.644 cu. ft. per second.

A difference of 0.2% in favor of two diameters.

A similar comparison was made in Observations 5 and 6 on the 44-in. pipe:

From all, or 50, readings.................. 43.059 cu. ft. per second.
From two diameters, or 14 readings........ 43.355 " "

A difference of 0.7% in favor of two diameters.

In Observations 9 and 10, on the 44-in. pipe:

From all, or 50, readings.................. 49.655 cu. ft. per second.
From two diameters, or 14 readings .... 50.089 " "

A difference of 0.86% in favor of two diameters.

The percentage of difference would seem to increase with the increase of velocity of discharge. As these percentages are within the limit of probable error of the meter, no conclusion in this respect can be drawn.

All other observations were taken from the two diameters, 1, 3, 5, 0, 7, 9, 11 and 2, 4, 6, 0, 8, 10, 12, drawn 45° from the horizontal. The conditions under which these experiments were conducted did not make it possible to take the time necessary to take readings from every hole in all the 22 observations.

Observation 4 was a repetition of Observation 3, on the 54-in. pipe, the readings for velocity being taken from two diameters in each case.

The discharge in these two observations was 49.222 and 48.869 cu. ft. per second, respectively—a difference of 0.7 per cent.

Plan of Conducting Experiments.—Each set of experiments required readings to be taken at three points. In the experiment on the 54-in. pipe, one observer was stationed at Piezometer No. 1, and two in the well, one for taking readings for the meter and one at the hook-gauge. One assistant was required for manipulating the meter.

The meter readings and hook-gauge readings were taken every two minutes and the piezometer readings every minute. No attempt was made to take the different readings of the piezometer heights at the

same instant, though they were all taken during the same interval of time. Before beginning each observation, the watches were compared and put approximately together.

The plan for the 44-in. was the same as for the 54-in. pipe experiments, except that the hook-gauge readings, in the well, were no longer necessary, and were only taken occasionally, to determine the amount of fluctuation, if any, in the height of water in the basin, and to check the height of Piezometer No. 2. One observer attended to this and also took occasional readings of head on the waste weir.

Regulation of Flow.—The minimum flow in each case was regulated by the normal capacity of the gravity system. No material reduction in this quantity could be made without drawing the hydraulic grade line below some of the summits, located from 4 to 15 miles below the settling basin. The height of water could be reduced on the highest summit about 5 ft. The height determined the maximum discharge, in each pipe, that could be obtained during the experiments.

The flow was regulated, during the 54-in. pipe experiments, from one of the 24-in. sluice-gates draining the basin.

In the 44-in. pipe experiments, the flow was regulated by opening two 6-in. blow-offs located in the valley a short distance below Piezometer No. 3, it being found necessary to open two blow-offs in order to get the maximum flow allowable.

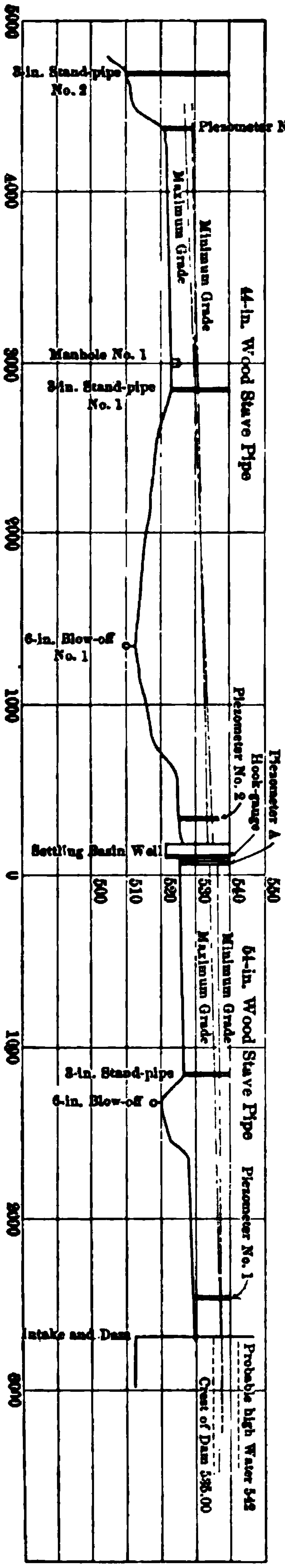
During Observations 1 to 7, inclusive, the 48-in. sluice-gate, at the entrance of the 44-in. pipe, was open about 9 ins. The sluice-gate was kept partly closed, in order to bring the hydraulic grade within the level of Piezometer No. 3.

During Observations 8 to 11, inclusive, the sluice-gate was wide open.

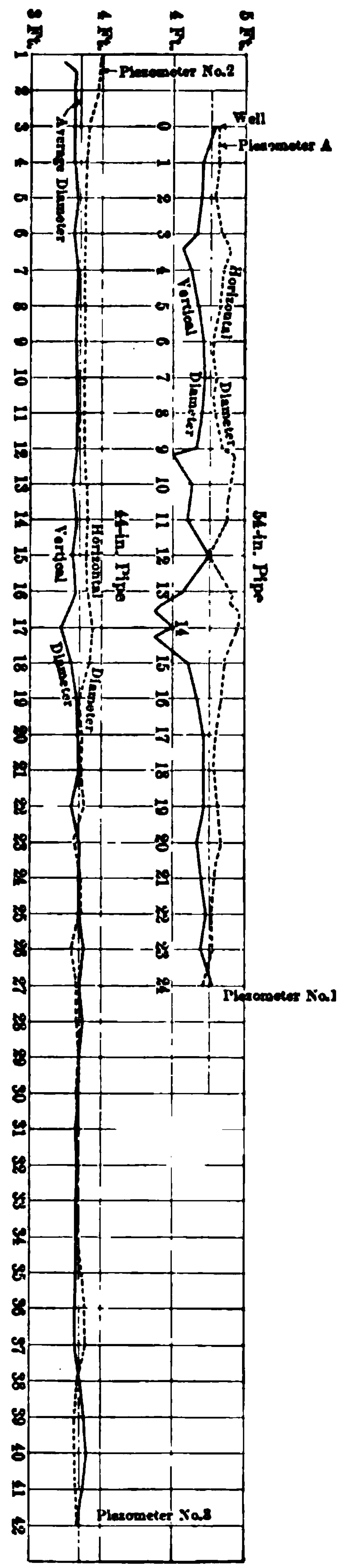
Size and Condition of Pipes.—Until two months after the experiments were made, when that portion of the pipes experimented upon was carefully examined, nothing was known of the condition of the interior. The writer was assured that there were no appreciable distortions, and that the pipe had been measured at intervals by the inspector, and found to be all right.

To be able to have some definite knowledge of the condition of the interior, and determine the average size, beyond question, the writer, with one of the city draughtsmen, Mr. Plachy, measured, at regular intervals of 100 ft., the vertical and horizontal diameters. Dimen-

PROFILE SHOWING LOCATION OF PIEZOMETERS AND HYDRAULIC GRADE LINES.



PROFILE SHOWING DISTORTION IN PIPE LINES EXPERIMENTED UPON.



FIGS. 8 AND 9.

sions were also taken in the 54-in. pipe, at some intermediate points where the distortion was excessive.

The interior of the 54-in. pipe was badly distorted in places, as is shown in Fig. 8, the profile of the vertical and horizontal diameters being shown. This distortion is accurate only at each 100-ft. station.

Fig. 9 shows the profile of the area. The average diameter was calculated by adding the averages to the vertical and horizontal diameters of each station and dividing by the number of stations.

The areas calculated from the average of the vertical and horizontal diameters is equivalent to the area of an ellipse of the same diameters. The assumption that the distortion is in the form of an ellipse is only approximately correct, as the top and bottom assume a flatter shape when distorted by earth pressure. The error from this cause would be very slight.

There was no rupture in the pipe, due to distortion, except at one point where the pipe evidently rested on a stone which had bulged in the bottom of the pipe for the width of two or three staves and splintered one stave slightly on the inside. Judging from the appearance of the interior, the writer does not believe that there was any considerable leakage due to distortion, and, from the nature of the ground, any leakage that would affect the results would be seen from the outside in the form of springs.

The maximum difference between the horizontal and vertical diameters at any one station in the 54-in. pipe was 1.187 ft.; the minimum average diameter at any one station, 4.343 ft., and the maximum average diameter at the well, 4.605 ft.

The maximum difference between the vertical and horizontal diameters in the 44-in. pipe was 0.448 ft.; the maximum average diameter at any one station, 3.736 ft.; the minimum, 3.672 ft.

There was some growth on the interior of the 54-in. pipe, in the nature of *Spongilla*. The whole interior surface, with the exception of the bottom, had scattering bunches of this little sponge-like substance, which required something of an effort to remove. They projected from the interior surface of the pipe about $\frac{3}{16}$ in., and each occupied a space of about $\frac{1}{4}$ sq. in. This growth seemed to be thickest on the top, and was absent on the bottom. The 44-in. pipe was entirely free from any growth. The interior surface was very smooth, and the

distortion very little, except in comparatively soft ground—indicating lack of care in tamping.

The pipes had been in use about one year when this examination was made. That this growth should be in the 54-in. pipe and not at all in the 44-in. pipe is, perhaps, due to the difference in velocity, in the former pipe the velocity being 2.282 ft. per second, and 3.464 ft. per second in the latter, under nominal conditions. It is not likely that the *Spongilla* could get lodgment as readily with the higher velocity, or, it may be that the settling basin, being a break in the continuity of the pipe, prevented them from spreading to the 44-in. pipe.

There is no question that this growth will, in time, reduce the discharging capacity of the 54-in. pipe, and more especially will it reduce the discharge of the smaller pipes, should it get lodgment in them.

Description of Tables.—Table No. 1 shows the principal data from the 54-in. pipe experiments.

Observations 1 to 11, inclusive, were taken to determine the loss of head and the velocity of flow, within the greatest range of level in the basin that it was possible to obtain.

In Observations 1, 3, 4, 5, 6, 7, 8, 9 and 10, the piezometer heights are the average of 29 readings, with 1-minute intervals, and the current-meter readings were taken on two diameters, each reading for velocity being taken for 1 minute, with 2-minute intervals. The hook-gauge height is the average of 15 readings, with 2-minute intervals.

Observation 2 was taken in the same manner, except that there were 50 hook-gauge and meter readings and 101 piezometer readings.

Observations 12 and 13 were taken without current-meter measurements, and with 15 readings each of Piezometer No. 1 and Piezometer *A* and the hook-gauge.

Columns 5, 7, 9 and 11 show the sums of the average readings in Columns 4, 6, 8 and 10, respectively, and the elevations given in the heading, and are the average elevations of the piezometer heights.

Section 1 includes the connections between the water above the dam and Piezometer No. 1. Section 2 includes the pipe between Piezometer *A* and the well. Section 3 includes the pipe between Piezometer No. 1 and the well.

TABLE No. 1—(*Continued*).

Number of observation. (1)	Loss of Head. Section 3. Length, 2 446.74 ft. Difference of level from Piezometer No. 1 to well. (18)	Difference of level from Piezometer No. 1 to well, plus increase at well. (19)	Net loss of head per 1 000 ft. (20)	Velocity, in Feet per Second. V_1, outer ring. (21)	V_2, second ring. (22)	V_3, third ring. (23)	V_4, center ring. (24)	Average: 54-in. pipe. (25)	Discharge, in Cubic Feet per Second. Outer ring: Area = 9.450 (26)	Second ring: Area = 6.498 (27)	Third ring: Area = 3.181 (28)	Center ring: Area = 0.409 (29)	Total discharge. (30)
1........	0.834	0.836	0.342	1.544	2.183	2.191	2.167	2.262	14.591	14.174	6.970	0.886	36.621
2........	0.835	0.837	0.342	1.536	2.175	2.199	2.191	2.276	14.515	14.123	6.995	0.896	36.529
3........	1.066	1.068	0.436	1.795	2.539	2.563	2.523	2.650	16.963	16.486	8.153	1.032	42.634
4........	1.358	1.366	0.558	2.069	2.936	2.960	2.912	3.067	19.552	19.063	9.416	1.191	49.222
5........	1.356	1.363	0.557	2.221	2.669	2.936	2.960	3.045	20.989	17.330	9.339	1.211	48.869
6........	1.634	1.645	0.672	2.298	3.268	3.276	3.267	3.408	21.716	21.219	10.421	1.336	54.692
7........	1.900	1.915	0.783	2.539	3.534	3.574	3.574	3.724	23.994	22.946	11.369	1.462	59.771
8........	2.076	2.094	0.856	2.669	3.727	3.776	3.785	3.924	25.222	24.199	12.011	1.548	62.980
9........	2.381	2.405	0.983	2.911	3.930	4.083	4.015	4.215	27.509	25.517	12.988	1.642	67.656
10........	2.606	2.632	1.076	2.992	4.205	4.278	4.253	4.419	28.274	27.308	13.608	1.740	70.925
11........	2.810	2.844	1.162	3.202	4.432	4.521	4.447	4.688	30.259	28.777	14.381	1.819	75.236
12........	0.802	0.804	....	....	....	....	....	....	....	....	....	....	....
13........	2.779	2.812	....	....	....	....	....	....	....	....	....	....	....

TABLE No. 1.—54-INCH STAVE PIPE.

Number of observation.	Date.	Duration of observation.	ELEVATIONS.								LOSS OF HEAD.					
			Above Dam. Elev. of Zero, 499.890.		Piez. No. 1. Elev. of Zero, 531.985.		Hook-Gauge. Elev. of Zero, 529.958.		Piez. *A*. Elev. of Zero, 532.445.		Section 1. Length, 232.14 ft.			Section 2. Length, 47.50 ft.		
			Average reading on gauge board.	Elevation of water above dam.	Average reading of Piezometer No. 1.	Elevation of water column.	Average reading of hook-gauge.	Elevation of water column.	Average reading of Piezometer *A*.	Elevation of water column.	Difference in level from dam to Piezometer No. 1.	Loss of head due to friction in pipe.	Observed entry head.	Difference in level from well to Piezometer *A*.	Calculated loss of head in pipe.	Increase of head between well and Piezometer *A*.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
	1901.															
1........	Dec. 14.	10.40 A. M. to 11.08 A. M.	....	....	4.933	536.918	6.126	536.084	....	....	......	......	......	......	......	0.002
2........	Dec. 14.	11.08 A. M. to 12.26 P. M.	....	....	4.932	536.917	6.124	536.082	....	....	......	......	......	......	......	0.002
3........	Dec. 14.	4.20 P. M. to 4.47 P. M.	....	....	4.858	536.843	5.819	535.777	....	....	......	......	......	......	......	0.004
4........	Dec. 15.	9.30 A. M. to 9.56 A. M.	....	....	4.715	536.700	5.383	535.341	....	....	......	......	......	......	......	0.007
5........	Dec. 15.	10.02 A. M. to 10.28 A. M.	....	....	4.716	536.701	5.387	535.345	....	....	......	......	......	......	......	0.007
6........	Dec. 15.	11.00 A. M. to 11.26 A. M.	....	....	4.638	536.623	5.031	534.989	....	....	......	......	......	......	......	0.011
7........	Dec. 15.	11.50 A. M. to 12.16 P. M.	....	....	4.571	536.556	4.698	534.656	....	....	......	......	......	......	......	0.015
8........	Dec. 15.	2.00 P. M. to 2.26 P. M.	....	....	4.515	536.500	4.466	534.424	....	....	......	......	......	......	......	0.018
9........	Dec. 15.	2.40 P. M. to 3.08 P. M.	....	....	4.441	536.426	4.087	534.045	....	....	......	......	......	......	......	0.024
10........	Dec. 15.	3.30 P. M. to 3.56 P. M.	....	....	4.378	536.363	3.802	533.760	....	....	......	......	......	......	......	0.029
11........	Dec. 15.	4.20 P. M. to 4.50 P. M.	....	....	4.284	536.269	3.501	533.459	....	....	......	......	......	......	......	0.034
12........	Dec. 22.	2.46 P. M. to 3.00 P. M.	37.287	....	5.000	536.985	6.211	536.169	3.738	536.183	0.192	0.078	0.114	0.014	0.016	0.002
13........	Dec. 23.	4.08 P. M. to 4.19 P. M.	37.317	....	4.591	536.576	3.817	533.775	1.352	533.797	0.631	0.259	0.372	0.022	0.055	0.033

TABLE No. 2—(*Continued*).

Number of observation.	Current-Meter Measurements. Velocity, in feet per second. Outer ring, 9.450 sq. ft.	Second ring, 6.498 sq. ft.	Third ring, 3.181 sq. ft.	Center, 0.409 sq. ft.	Discharge, in cubic feet per second. Outer ring.	Second ring.	Third ring.	Center.	Total discharge, in cubic feet per second.	Waste water from settling basin.	Net discharge in 44-in. pipe, in cubic feet per second.	Average velocity, in feet per second.	Loss of head, in feet per 1 000 ft.
(1)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
1......	1.634	2.248	2.207	2.183	15.441	14.596	7.020	0.893	37.950	0.515	37.435	3.464	1.067
2......	1.706	2.183	2.312	2.264	16.122	14.174	7.351	0.926	38.576	0.515	38.061	3.522	1.134
3......	1.755	2.345	2.385	2.296	16.585	15.226	7.587	0.939	40.337	0.517	39.820	3.685	1.191
4......	1.852	2.418	2.441	2.425	17.501	15.700	7.765	0.992	41.958	0.517	41.441	3.835	1.202
5......	1.892	2.531	2.514	2.507	17.879	16.484	7.997	1.025	43.355	0.516	42.839	3.964	1.330
6......	1.893	2.491	2.506	2.505	17.889	16.174	7.972	1.024	43.059	0.516	42.543	3.937	1.331
7......	1.941	2.596	2.612	2.555	18.342	16.856	8.309	1.045	44.552	0.518	44.034	4.075	1.404
8......	2.321	3.046	3.065	3.042	21.933	19.791	9.750	1.244	52.718	0.512	52.206	4.831	1.838
9......	2.224	2.912	2.984	2.895	21.017	18.909	9.492	1.184	50.601	0.512	50.089	4.635	1.757
10......	2.211	2.879	2.956	2.879	20.894	18.698	9.403	1.177	50.167	0.512	49.655	4.595	1.757
11......	2.126	2.774	2.823	2.782	20.091	18.012	8.990	1.138	48.221	0.511	47.710	4.415	1.618

TABLE No. 2.—44-Inch Pipe.

			Elevations.						Loss of Head.					
			Hook-gauge. Elev. of "0." 529.958.		Piezometer No. 2. Elev. of "0." 527.174.		Piezometer No. 3. Elev. of "0." 524.776.		Section 4. Length, 150.6 ft.				Section 5. Length, 4 041.02 ft.	
Number of observation.	Date.	Duration of observations.	Average of readings.	Elevation of water in well.	Average of readings.	Elevation of water in Piezometer No. 2.	Average of readings.	Elevation of water in Piezometer No. 3.	Difference in level, well to Piezometer No. 2.	Loss of head due to friction in pipe.	Loss of head due to velocity of water.	Loss in valve and basin.	Difference in level. Piezometer No. 2 to Piezometer No. 3.	Loss of head per 1 000 ft. of pipe.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	1901.													
1....	December 19th..	3.54 P. M. to 4.20 P. M....	5.868	535.826	6.163	533.337	4.250	529.026	2.489	0.160	0.186	2.143	4.311	1.067
2....	December 20th..	10.00 A. M. to 10.28 A. M...	5.768	535.726	5.833	533.007	3.650	528.426	2.719	0.171	0.198	2.355	4.581	1.134
3....	December 20th..	11.00 A. M. to 11.28 A. M...	5.722	535.680	5.647	532.821	3.234	528.010	2.859	0.179	0.211	2.469	4.811	1.191
4....	December 20th..	1.44 P. M. to 2.10 P. M....	5.657	535.615	5.447	532.621	2.747	527.523	2.994	0.189	0.228	2.577	5.098	1.262
5....	December 20th..	3.00 P. M. to 3.26 P. M....	5.592	535.550	5.144	532.318	2.166	526.942	3.232	0.200	0.244	2.788	5.376	1.330
6....	December 20th..	3.28 P. M. to 4.38 P. M....	5.587	535.545	5.140	532.314	2.160	526.936	3.231	0.200	0.241	2.790	5.378	1.331
7....	December 21st..	9.28 A. M. to 9.54 A. M....	5.557	535.515	5.117	532.291	1.843	526.619	3.224	0.211	0.258	2.755	5.672	1.404
8....	December 21st..	11.44 A. M. to 12.10 P. M...	5.118	535.076	7.245	534.419	2.015	526.791	0.657	0.283	0.362	0.012	7.628	1.888
9....	December 21st..	2.14 P. M. to 2.40 P. M....	5.234	535.192	7.411	534.585	2.713	527.489	0.607	0.263	0.334	0.010	7.096	1.756
10....	December 21st..	2.42 P. M. to 3.52 P. M....	5.233	535.191	7.409	534.583	2.706	527.482	0.608	0.264	0.328	0.016	7.101	1.757
11....	December 21st..	4.00 P. M. to 4.26 P. M....	5.362	535.320	7.593	534.767	3.417	528.247	0.553	0.244	0.308	0.006	6.520	1.613

The reading of the gauge board above the dam cannot be considered very accurate, as the smallest subdivision was 3 ins. It was taken to show by the observed entry head (Column 14) what error, if any, there might be in the heights of Piezometer No. 1.

	Observed entry head.	Calculated entry head.	Difference.
Observation 12..............	0.114	0.081	0.033
Observation 13..............	0.372	0.341	0.031

This would indicate that the error in the height of Piezometer No. 1 was very slight, if any; probably less than could be observed on the gauge board, as a part of this resistance must have been due to resistance at the entrance.

Column 19 shows the sum of Columns 17 and 18. Column 20 shows the quotient of Column 19 divided by the length given in the heading and multiplied by 1 000. Columns 21 to 24, inclusive, give the average velocity in each of the three rings and the center of the opening at the well. Column 25 gives the average velocity through the average section of the pipe, which is always larger than the average velocity at the opening, as the opening where the current-meter measurements were taken is larger than the average section of the pipe.

Columns 26, 27, 28 and 29 show the discharge, in cubic feet per second, of the respective rings of the opening, and Column 30 the total discharge, which is the sum of Columns 26, 27, 28 and 29.

Table No. 2 shows the principal data from the 44-in. pipe experiments. In these experiments there were only two sections of pipe: Section 4, from the well to Piezometer No. 2, and Section 5, from Piezometer No. 2 to Piezometer No. 3.

In Observations 1 to 7, inclusive, the sluice-gate at the entrance to the 44-in. pipe was open only 9 ins., causing the excessive resistance shown in Column 13.

During Observations 8 to 11, inclusive, the sluice-gate was wide open, showing the resistance at the entrance to be very slight, as this also includes the resistance in the basin and in the conduit from the well to the basin.

The current-meter measurements were made at the same place and under the same system as for the 54-in. pipe, except that from the total discharge is taken the waste water from the settling basin.

Columns 27 and 28 give the final results of velocity and loss of head.

Reliability of Results.—In conducting these experiments, the writer has endeavored to eliminate, so far as circumstances would allow, all sources of error, and confine the probable error within the limit that this method of measurement ought to give. He has, in some cases, perhaps, gone to more pains than necessary in order that the reader

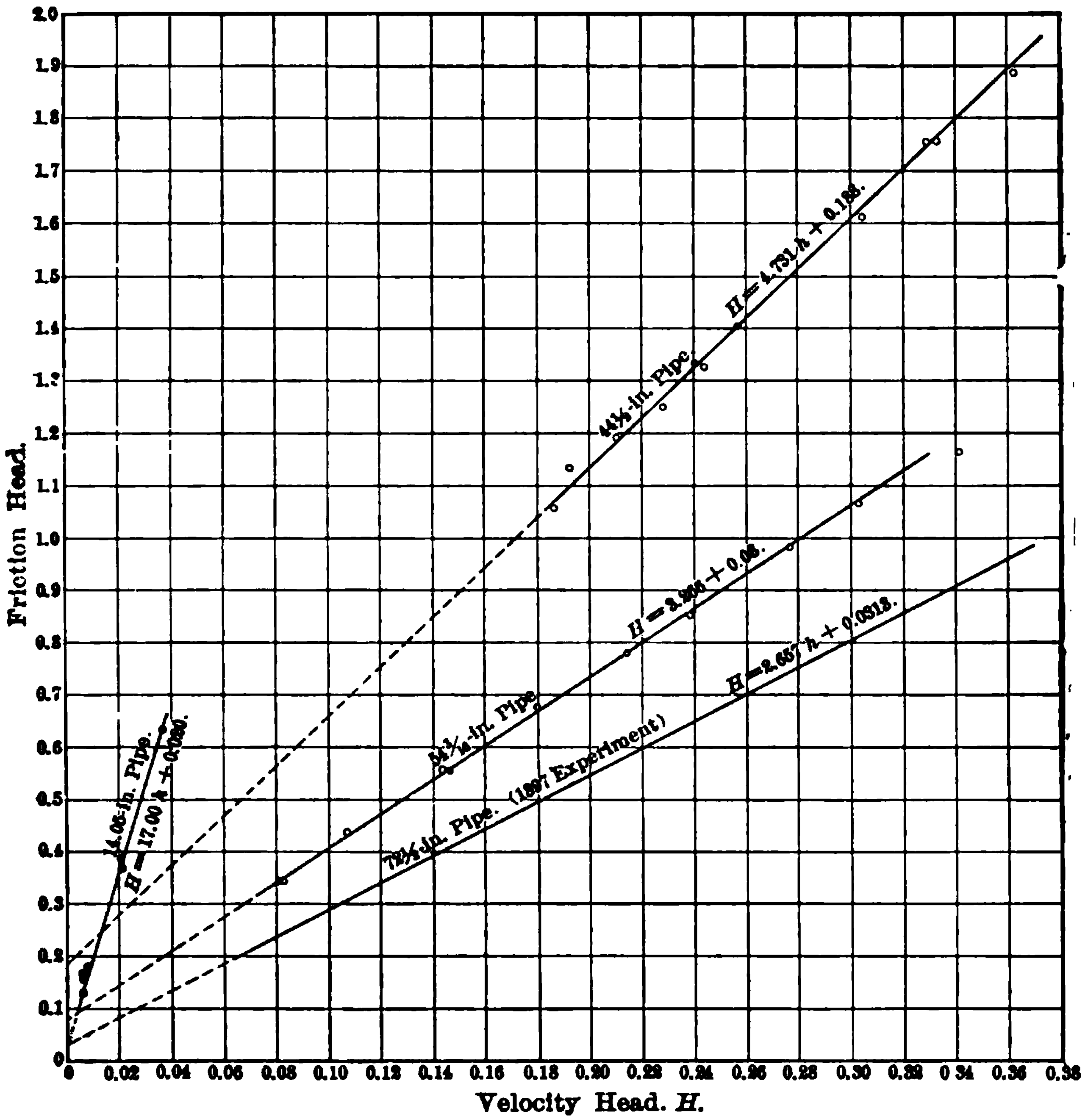


FIG. 10.

may understand clearly the conditions under which the experiments were conducted. If there has been any considerable error for which he has not allowed, it is to be hoped that it will be brought out in the discussion. The current-meter measurements are undoubtedly within 2% of the correct value, and the observations for loss of head are within 1 per cent. The size of the pipe is obtained from so many

separate measurements, 48 in the 54-in. pipe and 100 in the 44-in. pipe, that the probable error in the average size of the pipe must be very small.

Care was taken to guard against the accumulation of air in the connections between the piezometer tubes and the main pipe. That there was no considerable error in this respect is evident from the conformity of the individual observations to one line (see Fig. 10), with the possible exception of Observation 11 on the 54-in. pipe.

All observations of velocity are within 1% of this line, except Observation 11, which is within 2 per cent.

The very slight difference between the calculated and observed velocity head at the entrance of the 54 and 44-in. pipes proves the accuracy of the piezometer heights at Piezometers Nos. 1 and 2. The height in the well is checked by the height at Piezometer *A*.

Comparison with Other Experiments.—So far as the writer has been able to learn, all the available data regarding the loss of head in wood pipes are as follows:

1.—By James D. Schuyler, M. Am. Soc. C. E., on a 30-in. pipe line at Denver, Colo., the details of which are not available. The value of n, in Kutter's formula, is given as 0.0096.

2.—By Mr. Fred B. Gutillius, on the 24-in. pipe of the Butte City Water Company, in which he confirms the use of 0.01 as the value of n, in Kutter's formula.

3.—By Arthur L. Adams, M. Am. Soc. C. E., on an 18-in. pipe for the City of Astoria, Ore. The details of this experiment are given. The results show a value of n of 0.01, and $c = 132.9$. Only one observation was taken at a velocity of 3.605 ft. per second.

4.—By Arthur L. Adams, M. Am. Soc. C. E., on a 14-in. pipe for the West Los Angeles Water Company. In all, there were seven observations, the velocity varying from 0.691 to 1.531 ft. per second; value of c, from 99 to 113; value of n, about 0.011.

5.—By Messrs. Marx, Wing and Hoskins, on the 72-in. pipe of the Pioneer Power Plant, at Ogden, Utah. This is by far the most complete and satisfactory set of experiments yet conducted to determine the loss of head in wood pipe. The results have been fully written about and discussed.*

6.—By the writer, on 44-in. pipe, as described in this paper.

7.—By the writer, on 54-in. pipe, as described in this paper.

* *Transactions*, Am. Soc. C. E., Vols. xl and xliv.

In Experiments Nos. 1 and 2, of the foregoing list, no detailed information is available as to the circumstances and conditions under which the experiments were conducted, and in No. 3 no range of velocities was experimented upon.

The only data (so far as the engineering public is aware) which can be taken as criteria for the loss of head in wood pipe are those contained in Experiments Nos. 4, 5, 6 and 7, on 14-in., 44-in., 54-in. and 72-in. pipes, respectively. The range of velocities experimented upon in the 14-in. and 44-in. pipes is not as much as would be desired, and there is a wide gap from the 14-in. to the 44-in. pipe, and from the 54-in. to the 72-in. pipe. It cannot be said, so far as this information goes, that there is any very close conformity in the results, except in the two larger sizes, which agree fairly well; but it is difficult to see wherein they conform with the results on the 44-in. pipe; at least, no general law can be formulated that would seem to apply to all sizes, without the use of a coefficient having arbitrary values for the different sizes of pipe.

Fig. 11, showing the relation between velocity head and friction head, includes only the 1897 experiments made on the 72-in. wood pipe at Ogden. To avoid unnecessary complication, the other two experiments are not givèn. This experiment was chosen because at that time the age of the pipe was more nearly comparable with the age of the other pipes experimented upon.

It will be seen from Fig. 10 that in all these experiments the velocity head, as compared with the friction head, conforms very closely to a straight line. The evidence is very strong that a formula based upon this hypothesis is correct, as it most nearly fits the experiments so far conducted. Starting with this assumption, the equations for the different sizes of pipe become:

14-In. Pipe:

Let H = Friction head, in feet;

h = Velocity head, in feet per 1 000 ft.;

V = Velocity, in feet per second.

$$H = 17.00\, h + 0.0202$$

$$h = \frac{V^2}{2\,g}$$

$$V^2 = \frac{64.4}{17.00} H - 0.0202$$

$$V = 1.9463 \sqrt{H - 0.0202} \qquad (1)$$

44-In. Pipe:

$$H = 4.731\,h + 0.188$$

$$V = 3.6895\,\sqrt{H - 0.188} \qquad (2)$$

54-In. Pipe:

$$H = 3.266\,h + 0.08$$

$$V = 4.4405\,\sqrt{H - 0.08} \qquad (3)$$

72-In. Pipe:

$$H = 2.657\,h + 0.0313$$

$$V = 4.9232\,\sqrt{H - 0.0313} \qquad (4)$$

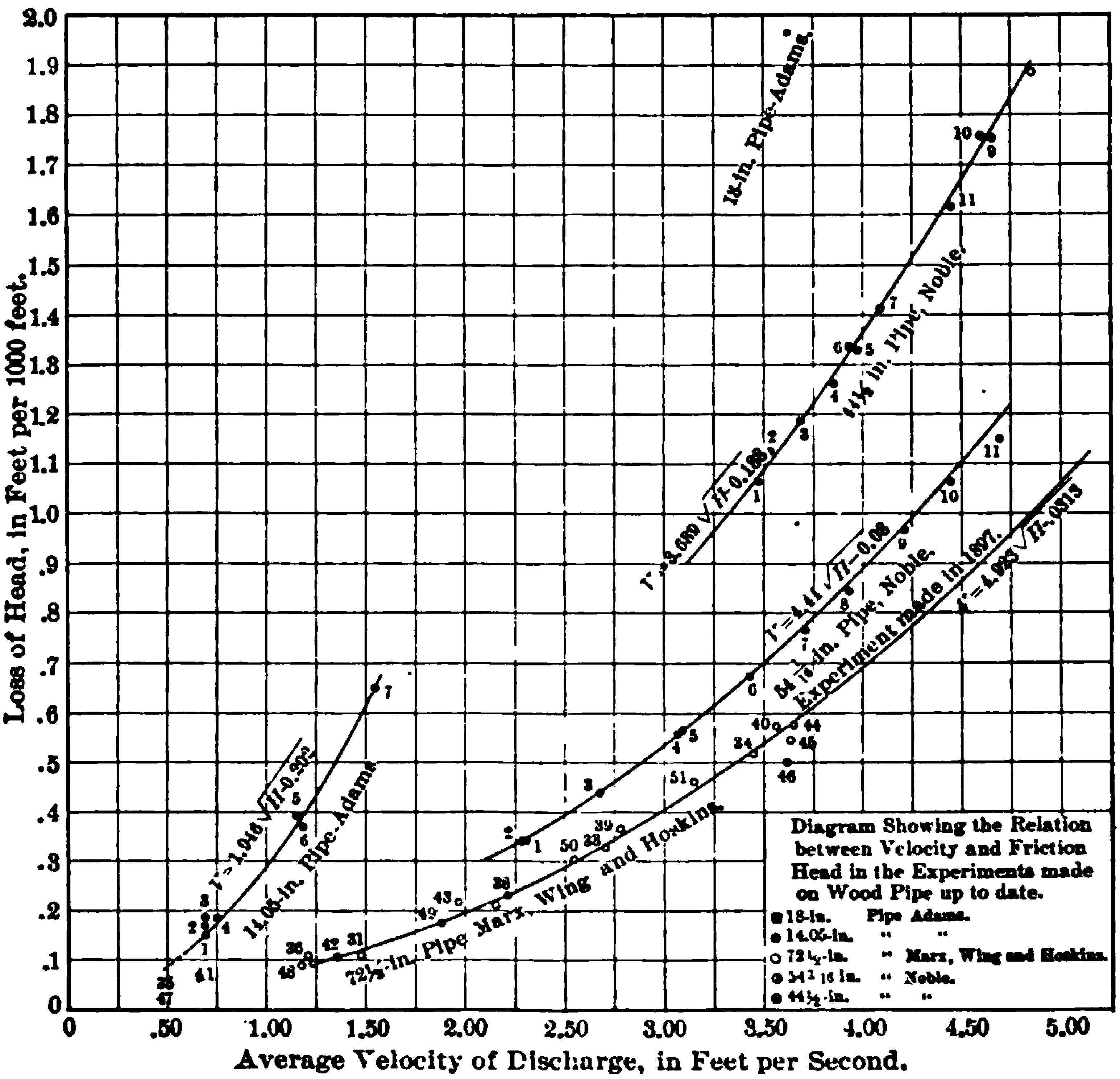


Fig. 11.

On the diagram, Fig. 11, the curves for these several equations (1, 2, 3 and 4), of the relation between V and H, have been plotted. The curves, of course, show the same conformity to the individual observations as in Fig. 10, and will give correct results for the individual sizes of pipe, within the range of the experiments on which they are based, and within the limit of accuracy of these experiments.

Without definite knowledge to the contrary, and until a more complete set of experiments can be conducted, it is safer to use these data as the basis for any formula for wood pipe.

These four equations are applicable to the individual sizes of pipe only, but they fit the experimental data more nearly than any other form of equation possible.

The writer, therefore, would propose the use of a general formula, based on these four formulas, of the following general form:

$$V = e \sqrt{D (H - b)} \quad \text{.........................} (5)$$

For the four sizes of pipe on which there are experimental data, the values of e and b are:

	e.	b.
14-in. pipe..................	1.799	0.0313
44-in. "	1.916	0.080
54-in. "	2.089	0.188
72-in. "	2.003	0.020

Interpolating for intermediate sizes of pipes for intervals of 6 ins. in size, these coefficients, in the formula, $V = e \sqrt{D (H - b)}$, are:

	e.	b.
14-in. pipe.............................	1.80	0.031
18 "	1.82	0.041
24 "	1.84	0.073
30 "	1.86	0.114
36 "	1.88	0.145
42 "	1.91	0.176
48 "	1.98	0.146
54 "	2.09	0.080
60 "	2.06	0.063
66 "	2.03	0.047
72 "	2.00	0.031

The values plotted from Formula 5, with the corresponding coefficients, produce the curves shown in Fig. 11. For the intermediate sizes of pipes, the values of e and b are proportional.

The original formulas (1, 2, 3 and 4), are of the form proposed by Mr. Fenkell in his valuable contribution* to the discussion on the second series of experiments on the Ogden pipe line. Mr. Fenkell,

* *Transactions*, Am. Soc. C. E., Vol. xliv, p. 78.

however, proposes that the smaller coefficient, b, is due to errors, and should be dropped. The writer contends that there are no reliable data to support this conclusion, except abstract theory, and that water, like gold, is only where it is found. It is better to swear by the values that we have been able to measure by practical tests than make allowances for errors that may or may not exist.

The above values of c and b are for pipes with smooth interiors, that have not been in use more than one year.

A further factor of safety should be allowed, to cover the increased loss of head when the pipe may be covered with a growth that would retard the flow.

APPENDIX.

Waste Weir.—The 24-in. sluice-gates for draining the basin leak considerably. There is also some leakage through the walls of the basin. This water, with the ground-water around the foundation of the walls, is all collected into a drain tile surrounding the foundation of the basin, and empties into a concrete-lined tunnel. At the mouth of this tunnel a weir, extending the width of the tunnel, was put in for measuring the amount of leakage from the basin. The crest of the weir was 3.04 ft. long, without end contractions; was 18 ins. above the floor of the tunnel, and had a perfectly free discharge. The height was measured from a fixed point, 1 ft. back of the weir, and carefully leveled to the crest of the weir, with a micrometer caliper, reading direct to 0.001 in. The height on the weir varied from 0.1250 to 0.1259 ft. The discharge, according to Bazin's formula, would be from 0.4895 to 0.4955 cu. ft. per second; according to Simpson and Blackwell's formula, 0.5115 to 0.5175 cu. ft. per second; according to Francis' formula, 0.442 to 0.446 cu. ft. per second.

Simpson and Blackwell's formula is probably most nearly correct, and is used to determine the amount of leakage. The leakage in the case of the lowest discharge amounted to 1.38%, and at the highest discharge to 1.07 per cent. Any possible error in the application of this formula would not result in an error of over 0.15%, which is well within the range of accuracy possible from other causes.

Velocity Head at Well.—After the first eleven observations had been taken on the 54-in. pipe, the writer concluded that, in order to find out whether there was any influence affecting the height of the water in the well which could not be attributed to the friction head, he would conduct two observations, one at the lowest and one at the highest velocity, with an additional piezometer (Piezometer A), located some

distance back of, and away from, any possible influence from the conditions prevailing at the well.

Observations 12 and 13 were conducted for this purpose. The current meter was not used. One observer was located at Piezometer No. 1 and one at Piezometer A, and also one at the hook-gauge in the well. Sixteen readings were taken at each place during each observation, with 1-minute intervals.

This experiment brought out the surprising result that the difference between the heights of water at Piezometer A and the well was less than the amount due to friction in the pipe. This increase of head was 0.002 at the lowest, and 0.033 at the highest velocity. The latter difference was sufficiently large to preclude any possibility of error from leveling, as the increase in difference would not involve the question of leveling.

The cause of this increase was not discovered until the pipe was emptied and the diameter measured, when it was found that the area of the end of the pipe next the well was 16.605 sq. ft., the average area being 16.050 sq. ft.

Assuming that this increase is due to velocity head:

Let V_1 = Velocity in the pipe where it enters the well;
V_2 = Average velocity;
H_1 = Head at the well due to velocity;
H_2 = Head at the average section due to velocity;
H = Velocity head (or gain of head at the well);
A_1 = Area of the pipe at the well;
A_2 = Average area.

Then:

$$H = H_2 - H_1$$

$$H_1 = \frac{V_1^2}{2\,g},\ H_2 = \frac{V_2^2}{2\,g}$$

$$H = \frac{V_2^2}{2\,g} - \frac{V_1^2}{2\,g}$$

$$\frac{V_1}{V_2} = \frac{A_2}{A_1},\ V_1 = \frac{A_2\,V_2}{A_1}$$

$$H = \frac{V_2^2}{2\,g} - \frac{A_2^2\,V_2^2}{A_1^2\,2\,g} = \frac{V_2^2}{2\,g}\left(\frac{A_1^2 - A_2^2}{A_1^2}\right) \quad \text{.............. (6)}$$

Applying this equation, in order to find the calculated value of the gain in head at the well during Observation 13, we have:

$$V_2 = 4.651;$$
$$A_1 = 16.605;$$
$$A_2 = 16.055;$$
$$2\,g = 64.4.$$

From Equation (6), $H = 0.024$.

The observed value of H was 0.033.

Taking into account that this difference (0.009 ft.) may be partly due to errors in leveling and partly to error in the area of the pipe at the well, which was measured by two diameters only, the results are sufficiently near to conclude that the effect was due to velocity head.

This effect of velocity head, due to a diverging pipe entering a reservoir, was the subject of a very elaborate series of experiments carried on by the late James B. Francis,* Past-President, Am. Soc. C. E., at Lowell.

He gives a very clear account of the experiments and results, and shows that the maximum effect from a submerged diverging tube of that particular design was an increase of the velocity in the smallest section of the tube of 239% above the theoretical velocity due to the head.

Mr. Francis does not account for this increase. Whether the above formula for head on Venturi, which is the same as given for the Venturi meter, would apply to the results of Francis' experiments, would be interesting to know.

Resistance of Fittings.—As there are, in the entire length of the gravity system, about ninety-five manholes, forty-three blow-offs, twenty-one 3-in. stand-pipes, two 36-in. overflow stand-pipes, thirty-two air-valves and three 36-in. gate-valves, making in all about 196 fittings—not including elbows and T-connections inside the city limits—it was important to find out what influence these fittings have on the total loss of head in the pipe line; it being the original intention to find the loss of head in each kind of pipe, in the gravity system.

For this purpose a differential oil gauge, Fig. 6, was made on much the same plan as described in the paper† by Messrs. Williams, Hubbell and Fenkell, though the writer was not at the time aware of the existence of such a gauge in practical use. The gauge was a rather crude affair, made from such materials as could be obtained in Seattle at the time, and consisted of two glass tubes, $\frac{5}{8}$ in. outside diameter, connected with boiler gauge-glass fittings, so that the tops of the glasses had free communication, and the bottom of each glass could be connected through two pieces of $\frac{1}{2}$-in. hose with the main pipe above and below the fitting, the resistance of which it was desired to obtain. The connection with the pipe was made in the same manner as described for connecting the piezometer tubes.

Both gasoline and coal-oil were used. Gasoline, which was first tried, was found to be objectionable on account of its volatility and its power of absorption. Coal-oil was found to be most serviceable, for the reasons mentioned in the paper by Messrs. Williams, Hubbell and Fenkell.

* Francis' "Lowell Hydraulic Experiments," pages 222 to 232.

† "Experiments at Detroit, Mich., on the Effect of Curvature upon the Flow of Water in Pipes." *Transactions*, Am. Soc. C. E., Vol. xlvii, p. 1.

The gauge was calibrated by connecting each side with a barrel filled with water. One barrel was provided with a hook-gauge for measuring the height of the surface of the water, and the other barrel with a fixed hook, so that the level of the surface would be maintained. The two barrels were first connected, and the level of the surface in each barrel brought to the level of the fixed hook.

The first readings were then taken from the hook-gauge and differential gauge, with the level in the two barrels the same. The connection between the two barrels was then closed and the level in the barrel containing the hook-gauge was repeatedly lowered, and readings taken until the full range of the scales on the differential gauge was covered.

The results of this calibration made the specific gravity of gasoline 0.720 and coal-oil 0.803. The temperature was about 40° during both experiments.

The result of each experiment is the average of from 15 to 20 readings, with 1-minute intervals.

TABLE No. 3.

	Reading of difference gauge reduced to water head.	Length of pipe.	Friction head in pipe.	Friction head in fitting.
44-in. pipe, Blow-off No. 1........	0.0212	14.20	0.0151	+0.0061
" " " No. 2........	0.0149	16.43	0.0175	−0.0026
" " Manhole..............	0.0070	8.36	0.0089	−0.0019
54 in. " Blow-off..............	0.0104	17.00	0.0058	+0.0046

The apparent friction head at these fittings is undoubtedly influenced by the velocity head due to the considerable differences in area which exist in this class of pipe, and would account for the minus quantities in the second and third experiments.

That the differential oil gauge, with proper precautions, is a most delicate and accurate device for measuring differences of pressure, the writer has no doubt. It was some little time before consistent results could be obtained; any irregularity or inaccuracy was readily detected by reversing the hose connections so that the difference of pressure came on opposite sides of the gauge. It was found that even a small amount of air suspended in the water or oil columns, or lodged in the fittings, vitiated the value of the results. This, however, could be eliminated by reversing the connections and taking the average of the two sets of readings. It was also found that globules of water would cling to the sides of the glass in the oil column and affect the results.

The writer's plan for making any future experiments of this nature would be to make the gauge in the form of a continuous, inverted,

glass U-tube, not less than 1 in. in internal diameter, connected at the top with a small glass tube and valve for letting out air and putting in oil. The gauge should be entirely free from any iron or metal fittings where they would come in contact with the oil column, as it is desirable to see the entire column and be sure there is no air or water to reduce or increase the specific gravity of the oil. The connections to the pipe should be free from places where air could lodge, and the main pipe should be tapped at one side of the center to prevent air from entering the connections during the course of the experiment.

In the measurement of velocity head in the Venturi meter, the writer believes that the oil gauge would give much more accurate and reliable results, though he is not aware that it has ever been tried. It is possible that fluctuations might be violent, and interfere with getting a close average. Its effect, however, would be to magnify the conditions prevailing with the mercury gauge, and thus make the average reading more accurate. Where very accurate readings are required with either the piezometer or the differential gauge, better results could be obtained by eliminating the momentary fluctuations of pressure which exist in all pipe lines of any considerable length. This can be done by connecting the pipe leading from the gauge to the main pipe with a reservoir of small capacity; ordinarily a 6-in. stand-pipe would be sufficient where the connection with the main pipe is small. These momentary fluctuations are of no value, as far as the piezometer heights are concerned, and are of constant annoyance to the observer.

This subject also brings to the mind of the writer the possibility of getting much more satisfactory and consistent results in pipe lines by using the differential oil gauge to determine the friction head in the pipe lines, by making connection with a comparatively short length of pipe, say 100 ft. This would eliminate many sources of error. The conditions could be more readily determined, and the loss of head per 100 ft. could be read on the differential gauge direct. This method would seem to be particularly appropriate where the pipes are under considerable pressure, making it possible to dispense with mercury manometers and the complication arising from necessary corrections for temperature. It would be possible to select a length of pipe that would be mostly free from influences outside of the one influence sought. Take the case of the lowest frictional resistance encountered in these experiments, viz., 0.0342 ft. in 100 ft.: The difference gauge using coal-oil would show a difference of 0.1710 in 100 ft., which could be read (after the momentary fluctuations were eliminated) to 0.001 ft., bringing the results within a probable error of 1%, which is better than can be done with ordinary open-tube piezometer readings, where connections are made less than half a mile apart.

Value of Coefficients in Kutter's Formula.—The values for c and n, in Kutter's formula, would seem to conform to the results from the Ogden experiments, but differ widely from Mr. Schuyler's experiment on the 30-in. pipe at Denver, and the experiments by Mr. Adams on 14 and 18-in. pipes.

In Kutter's formula,
$$V = \frac{a + \frac{l}{n} + \frac{m}{s}}{1 + \left(a + \frac{m}{s}\right)\frac{n}{\sqrt{R}}} \sqrt{R S}.$$

$$c = \frac{a + \frac{l}{n} + \frac{m}{s}}{1 + \left(a + \frac{m}{s}\right)\frac{n}{\sqrt{R}}}$$

TABLE No. 4.—54-INCH PIPE.

Observations.	V.	$S \times 1\,000$.	c.	n.
1	2.282	0.342	116.08	0.0130
2	2.276	0.342	115.77	0.0131
3	2.650	0.436	119.33	0.0127
4	3.067	0.558	123.13	0.0125
5	3.045	0.557	121.36	0.0126
6	3.408	0.672	123.66	0.0124
7	3.724	0.733	125.19	0.0123
8	3.924	0.856	126.16	0.0122
9	4.215	0.963	126.46	0.0122
10	4.419	1.076	126.72	0.0122
11	4.688	1.162	129.21	0.0120

TABLE No. 5.—44-INCH PIPE.

Observations.	V.	$S \times 1\,000$.	c.	n.
1	3.464	1.067	110.12	0.0134
2	3.522	1.134	108.60	0.0136
3	3.685	1.191	110.83	0.0133
4	3.853	1.262	112.63	0.0132
5	3.964	1.330	112.87	0.0131
6	3.972	1.331	113.05	0.0131
7	4.075	1.404	112.93	0.0131
11	4.415	1.627	113.67	0.0130
10	4.595	1.757	113.83	0.0130
9	4.635	1.757	114.82	0.0129
8	4.831	1.838	115.45	0.0129

The writer can offer no suggestion as to why the value of c should be less and n greater in the 44-in. than in the 54-in. pipe, when, to conform to the results of other experiments, it should be the reverse. The same discrepancy will be noticed in the value e in the formula, $V = e\sqrt{D(H - b)}$, proposed by the writer.

The value of n, as in previous experiments, decreases with the velocity, while c increases; whereas the value of e, in the formula, [illegible] $(H - b)$, remains constant for all velocities in the same size of pipe, within the range of the experiments so far conducted.

The writer is indebted to Mr. Reginald H. Thomson, City Engineer of Seattle, without whose moral and financial assistance the experiments could not have been undertaken; to Mr. H. W. Scott, Assistant City Engineer, for his assistance as an observer, and for maps and other information regarding the gravity system; to Mr. E. McCulloh, for his valuable assistance; to A. H. Fuller, Assoc. Am. Soc. C. E., Professor of Civil Engineering, Washington University, and to W. H, Plachy and J. C. Atwood, who assisted in taking the observations.

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PAPERS AND DISCUSSIONS.

THE PROTECTION AND IMPROVEMENT OF FORESHORES BY THE UTILIZATION OF TIDAL AND WAVE ACTION.

By R. G. Allanson-Winn, M. Inst. C. E., I.
To be Presented October 15th, 1902.

How to permanently safeguard a given line of frontage from the erosive action of the sea at low cost?

This is the problem constantly before the engineer engaged in foreshore protection work. The question of cost depends upon what is to be protected; for an outlay which would be held to be quite reasonable if expended on the protection of a line of railway, the esplanade of a fashionable watering-place, or an important dock or harbor, might be quite prohibitive in the case of mere agricultural land.

Sea-walls, embankments and groynes have all been tried with varying success; and it must be admitted that large sums have often been expended without due regard to the requirements, or an adequate consideration of the complicated conditions obtaining. It is often a matter of extreme difficulty to collect sufficient data to enable one to

Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

set to work with any degree of confidence. Among some of the important points upon which information is required may be mentioned:

1.—Range of tide.

2.—Direction, duration and intensity of prevalent winds.

3.—Direction, duration and intensity of most destructive winds.

4.—Direction and force of 'long-shore currents, surface and bottom velocities being taken at high water, half-tide, and low water.

5.—Percentage of material per cubic foot of water carried in suspension; samples to be taken from the surface and close to the bottom.

6.—Quantity of shingle or other traveling detritus, and extent to which it is moved in different conditions of wind, waves, etc.

7.—Nature of marl, sandstone, or other material of the foreshore undergoing erosion.

8.—Extent to which the sea bottom is undergoing change, especially in the matter of the formation or alteration of submerged banks, causing alteration in the direction of currents.

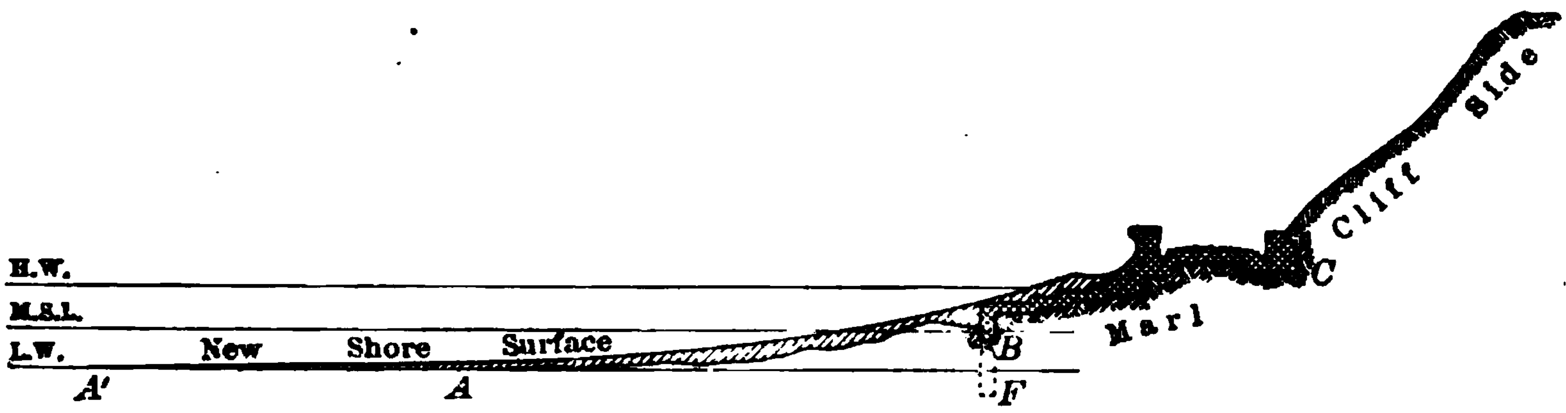
In addition to the foregoing, and most troublesome of all, are the quite indeterminable concurrences of high tides and storms, which, though they cannot be predicted, or calculated with any degree of certainty, must be expected and allowed for. Needless to say, the collection of the necessary data requires both intelligence and experience, for it must be done with a full knowledge of what is required to suit each individual situation—a point of vital importance in one case being of quite secondary consideration in another.

Of all the methods of dealing with sea encroachments, systems of groyning should engage our chief attention, because, by their proper application, we are enabled to direct those great carrying forces of the water, and thus provide for the deposit and retention of millions of tons of sand or shingle which would otherwise be swept away.

With regard to walls, experience shows that they are unsatisfactory, unless they are either protected by natural barriers of shingle

or sand, or built on a scale altogether prohibitive, except for the safeguarding of valuable building property, railways, or docks.

It will thus appear that if we can succeed in accumulating a permanent barrier which will prevent the sea from reaching a wall, except in the form of spray and foam, then, and then only, are we justified in erecting a wall of slight construction.



LIGHT CONCRETE ESPLANADE WALL, STEPPED. OFTEN USED IN CONJUNCTION WITH CASE GROYNES, IN FORESHORE PROTECTION.

FIG. 1.

The section, Fig. 1, shows a wall, *B C*, the foundations of which have been taken well down into the marl, say even as far as mean sea level. Very possibly such a wall may stand for years, but it cannot be relied upon, for, if the shingle, shown in the section as lying above the marl surface, gets washed away, successive laminæ become eroded until, as time goes on, the foundations become exposed, and toe-walls have to be added at great expense, if the wall is to be saved. The writer has now under consideration a sea-wall 20 ft. high, which is being thus undermined, year after year. This wall supports high and easily eroded cliffs, on top of which, and quite close to the edge, runs an important treble line of railway. If the wall goes, the railway must also go, and the anxiety of the engineers, as each line of toe-wall becomes necessary, may be easily imagined.

In all cases where sea-walls alone are resorted to—and more particularly where railway lines or valuable house property are in jeopardy—the writer strongly recommends that the foundations should be at once taken down well below low-water level.

Thus, in the section, instead of stopping short at *B*, the engineer should have taken his foundations down to the point *F*, and thus, at increased initial cost, secured a vast amount of additional future safety.

There is one system of groyning, however*—that discovered by the

* See "The Constructive Power of the Sea." *Proceedings*, Inst. C. E., Ireland, January, 1900.

late Mr. Edward Case—which may be relied upon to collect and retain traveling material in such a way as to protect the toes of walls. Mr. Case took a long step in advance when he promulgated his theory that every shore has its own inclined surface of repose, and that that surface could be brought about by accumulations mainly derived from the traveling material between mean sea level and low-water mark.

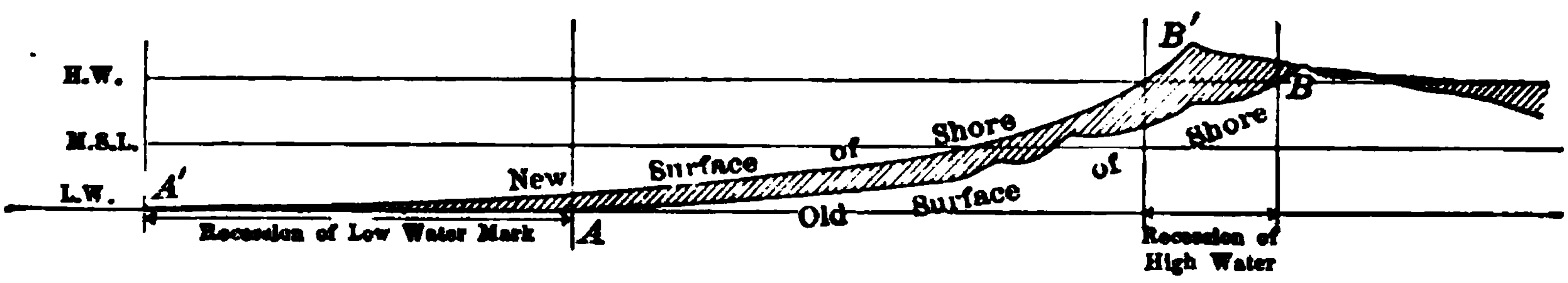
If, he argued, a shore can be made to once acquire this surface—from which there is the minimum chance of alteration through the action of waves and currents—sea-walls, properly so-called, will not be as necessary as formerly for the protection of esplanades, seaside roads, etc. If a good "full" of beach can be secured, a comparatively light retaining wall will be sufficient, for the beach itself can be relied upon as a protection for the foundations, and there will be the satisfaction of having saved heavy expense in costly concrete blocks, etc., which would otherwise have been considered necessary.

Experience and close observation convinced Mr. Case that there was an extensive travel of shore material between mean sea level and low-water mark, and experiments proved that, by the use of long, low groynes, the material-bearing lower currents could be directed shoreward until sufficient deposit had taken place, and the desired surface of repose was acquired. He sought to build up the shore from its lowest point—*i. e.*, low-water mark—and in doing this he was but following the usual custom, for a shore is, after all, but an embankment with a very flat gradient, and, as is well known, every embankment must be started from its foundation or lowest point. Being quite convinced of the soundness of his theory, Mr. Case designed groynes of a form which is simple, inexpensive, and capable of rapid construction. These are low groynes, and are entirely of timber. They were first applied at Dymchurch, which must be regarded as the cradle and home of the Case system. They commence about mean sea level and run down to low-water mark. Among the advantages claimed for those groynes may be named the following:

1. They are economical, as regards time, labor and cost of materials.
2. No plant or skilled labor is required, though experience is needed in the adjustment of the planking.
3. All the timber used is of the same scantling.
4. Manipulation is easy, and the cost of repairs and maintenance is very trifling.

As regards the action of these groynes, it may be observed that the principle of small obstructions and the multiplication of small results gradually brings about the desired change. There is nothing sudden, and no abrupt interference with existing conditions. The deposits are gradually brought about, and at the proper place for the correct building up of the long, smooth bank which is destined to protect the shore at high-water mark. It may also be noted, that the services of that restless, never-tiring workman, the sea, are enlisted, and that the winds and waves help to stir up and carry particles which are caught by the groynes and directed shoreward. In fact, it may be said that the destructive forces of the elements are converted into constructive forces. The small and gradually accumulating silts are encouraged at low-water mark, and further encouraged until the shore is built up to the required shape.

The correct form of any shore composed of beach or any other shiftable material is a gradually sloping surface, the section of such shore between high and low-water marks being approximately an ellipse, the construction of which depends upon the range of tide and the horizontal distance between high and low-water marks. (See Fig. 2.)



TYPICAL SECTION SHOWING ACTION OF CASE GROYNES IN PUSHING SEAWARD BOTH HIGH AND LOW-WATER MARKS, AND APPROXIMATE SURFACE PRODUCED BY LOW GROYNES. THE ACCRETION OF SHORE MATERIAL SHOWN BY SHADED PORTION.
N.B. VERTICAL SCALE EXAGGERATED.

Fig. 2.

Very few natural shores lie at this desirable inclination. The section of a shore between high and low-water marks is seldom a true ellipse, but the nearer the sections of any shores approximate to true ellipses the less damage is done by the sea along that particular portion of the foreshore. In some instances, the curve being nearly perfect and free from any abrupt angles or changes throughout its entire length, the waves roll harmlessly in at the flood tide, and equally harmlessly retreat with the ebb.

Take the case of a railway truck running down an incline of rails and gaining sufficient momentum to run up another incline. If the

rise is quite gradual, and there are no angles or obstacles of any kind, no damage will be done; the truck will run up until stopped by the ever-acting force of gravity, and will then run back again without doing any harm. But if any obstacle is placed on the line, or there is any break in the continuity—any abrupt angle, as it were—something has to go; something is injured or broken.

If any shore, at random, be examined, a well-defined angle will probably be found, somewhere about mean sea level, where the beach leaves off and the sand begins, the beach angle being the steeper from a point above high-water mark to the junction with the sand, and the sand from this point lying at a much flatter inclination right down to low-water mark. No two shores possess exactly the same characteristics. It may be possible to find a couple of places where the nature of the material, range of tide, prevailing wind, etc., seem to be very much the same, but a closer examination will reveal some factor which they have not in common; some particular current, or some sunken bank, perhaps far out at sea.

Roughly speaking, it may be said that there are six types of coast line:

1. The rock-bound coast, where erosion goes on so slowly as to be practically imperceptible—*e. g.*, Cornwall, Aberdeen, North of Ireland.
2. The line where denudation of beach and other shore material is a serious menace to sea-walls, esplanades and cliffs, composed of more or less easily eroded material—*e. g.*, Brighton, Hastings, Folkstone, Ventnor, Shanklin, Sandown, the Holderness Coast of Yorkshire, and, generally, the sites of watering-places all around the coast.
3. Where masses of shingle are being driven inland.
4. Where the shingle has disappeared and there is no "full" of beach to arrest the encroachment.
5. Where shores are so cut about that they consist of bare rocks, pools of water, wet sand and mud, and are therefore most unsuited for recreation grounds for children and others—*e. g.*, Worthing and Herne Bay.
6. Where extensive scours have been caused on the lee sides of high groynes, as at Hastings, St. Leonard's and Brighton.

As is almost invariably the case with any new contrivance or method, the low groynes were at first looked upon with contempt, partly on account of their slight nature and their cheapness, but more especially because of their novelty. There were also many people who argued that the groynes might answer well enough on a sandy shore like Dymchurch, but that they would be of no use in places where shingle predominated, or where shingle and sand together were to be dealt with. To prove how incorrect these arguments were, we have only to point to Southwold, where there is only shingle, and to Deal, where both shingle and sand are to be found. The writer believes that the principle is correct for any shore whatever, with any range of tide, save, alone, a rock-bound coast.

Dymchurch was in a very bad way when Mr. Case put down his groynes in 1894. The shore then consisted of soft mud alternating with pools of water and wet sand. The Dymchurch sea-wall, extending for more than 3 miles and protecting some 60 000 acres of the Romney and adjacent marshes, was in a precarious condition, and constantly needing extensive repairs. In 1898 matters had improved so much that hard, dry sand had taken the place of the mud and swales, and from 7 to 8 ft. in depth had accumulated near the toe of the wall, which was then practically saved. If placed end to end the Dymchurch groynes would to-day extend for a distance of more than 10 miles. They vary from 300 to 1 000 ft. in length, and have been instrumental in collecting more than 1 500 000 tons of shore material, which lies at a satisfactory slope, and affords an excellent playing ground for children. How many places would be improved by such sands, and how much would such an acquisition add to the value of house property where at present no such sands exist! It is noteworthy that not one of the piles in the Dymchurch shore is set in a solid foundation, and yet there they are to-day, as they were in 1894, having in those few years completely changed the character of the shore and saved the sea-wall. A visit to Dymchurch would go far toward convincing the skeptic, for it would afford a practical illustration of how great resnlts may be produced by the correct application of simple means.

Fig. 1, Plate XXVI, is a photograph taken at Bexhill, showing the unsatisfactory condition of the shore near low-water mark, and the absence of sand where most required for a children's playing ground.

Fig. 2, Plate XXVI, is also a photograph at Bexhill, and shows the unevenly deposited shingle and the eroded condition of the shore near the low-water mark. The Bexhill shore might be enormously improved by the application of the Case system.

At Deal, Southwold, Cromer, Mundesley, and many other places on the East Coast of England; at Borth in Wales, and at Middlekirk and Mariakirk in Belgium, the system has been applied with great success. In 1898 the writer was called in to advise as to the best means of saving the Glenbeigh foreshore, which faces west, and is exposed to the full fury of the broad Atlantic; indeed, standing on this wild Kerry shore, in a westerly or northwesterly gale, one can realize to some extent the carrying power of the ocean. The writer's experience of this foreshore goes back more than 30 years, and, although he cannot remember the time when there was no encroachment, it is only within the past 16 or 17 years that the advance of the sea has become very marked. Nine Case groynes were erected in 1898, and they have been instrumental in collecting a large quantity of sand between mean sea level and high-water mark, and have improved the shore and arrested the progress of the sea. It is only fair to mention that the works at Glenbeigh are very incomplete, the private owners of the estate being unable to afford the cost of a full and efficient scheme.

At Youghal, in County Cork, the sea broke in and flooded 600 acres of land, at the same time jeopardizing the safety of the Great Southern and Western Railway Company's line. An embankment was run across the breach, and the Case system of low groynes applied simultaneously on a scale sufficiently extended to ensure success. The results have been most satisfactory; that portion of the shore which had been cut out, down to the very foundation, having been completely restored in less than a year; as much as 8 000 tons of sand per 100 ft. of frontage having been accumulated by the action of the groynes over a considerable portion of the coast line. The writer formally handed over this work in April, 1901, and it is only fair to say that all interested in the welfare of Youghal are completely satisfied with the rapidity of the work of reclamation.

In proof of the favor with which this work is regarded, it is only necessary to mention that early in the present year, 1902, the Great Southern and Western Railway Company ordered a further extension of the groynes to the west. This additional protective work is now being

FIG. 1.—BEXHILL, SHOWING UNSATISFACTORY CONDITION OF SHORE NEAR LOW-WATER MARK.

FIG. 2.—BEXHILL, SHOWING UNEVENLY DEPOSITED SHINGLE AND ERODED CONDITION OF SHORE NEAR LOW-WATER MARK.

carried out under the writer's supervision. It includes a long breast-work wall, five long, low groynes, and an extended sluice-run. The shore in many respects resembles those at Atlantic City and Long Branch, though the New Jersey coast line is more favored—from a groyning point of view—on account of the greater travel of shore material. The writer would be pleased if those interested in the protection of any portions of the United States coast could see for themselves the wonderful results brought about at Youghal in little more than one year, and he has little doubt that they would be convinced by such ocular evidence.

At Bray, near Dublin, the Case groynes are now doing good work, though the results are likely to be less rapidly achieved, on account of the situation and the existence of a sea-wall, which causes a good deal of scour. This work is being carried out for the Dublin, Wicklow and Wexford Railway Company, whose line is now seriously threatened, at intervals, all the way from Killiney to Wicklow on the East Coast of Ireland.

Here there are two obstacles to satisfactory progress in "shore building"—obstacles which do not appear to exist in any of the shores examined by the writer on the occasion of his visit to America—which are of such a serious character that it is out of the question to expect rapid improvement, as at Youghal:

1. The existence of a 20-ft. sea-wall, high-water mark being some 4 ft. up the face;
2. The wholesale and continuous abstraction of shingle, sand, and gravel by one of the foreshore owners.

This shore has been allowed to go too far, and is almost past saving, though there would still be hope if the removal of shore material could be stopped. This material is sold for building purposes at a considerable gain to the owner, but to the great detriment of the railway line which serves the public.

One might almost say, in this case, that the rapacity of Man is leagued with the destructive forces of Nature to defeat the ends of Science.

Fig. 1, Plate XXVII, is a photograph taken at Bray on August 27th, 1901, to the south of the south box groyne—just before its demolition —25 ft. at right angles to the wall opposite the first step in the toe-wall, looking northwest. This photograph shows the deep scour

beneath the piles in the late groyne and the scour under the toe-wall.

Fig. 2, Plate XXVII, is a photograph taken at Bray, and shows the accumulation of sand along a shore where, previous to the erection of the Case groynes, no sand was to be found.

Fig. 3, Plate XXVII, is also a photograph taken at Bray, and shows the accumulation of sand and shingle on the lee side of the high groyne where a deep scour previously existed.

The writer's attention has been frequently directed to the danger of dealing with small, isolated portions of a line of coast, especially where the sections show a very symmetrical accumulation between the highest "full" and low water.

When asked, a few months ago, to report and advise as to the best means of stopping the encroachment of the sea on the Murrough Shore, at Wicklow, what struck him most was the remarkable symmetry of the sections all along that portion of the shore for a distance of more than three-quarters of a mile. The tiers of "fulls" lay so evenly in exact horizontal contour lines that they might have been produced by a gigantic cornice mould. The sections subsequently taken fully confirmed this, for, when superimposed, the plotted sections showed differences of only a few inches.

The next thing which occurred to the writer was the danger of placing any obstacles which might cause the sea to interfere with this symmetry—any obstruction of a solid nature which would cause an uneven scouring action and thus a direct attack by the sea at some definite point, which, in all probability, would be far worse than the gradual but uniform wasting away at present taking place at the rate of about 12 ins. annually all along the entire shore.

Rather than run the risk of almost certain damage by the erection of a few groynes only, the writer refused to have anything to do with the work unless he had the authority of the Wicklow Urban District Council to deal with the shore as a whole, and he then suggested a certain number of Case groynes at intervals of about 100 ft. all along the shore. This could only have had the effect of uniformly increasing the shore material—it could not have caused a scour at any particular point. A short time since, the Urban District Council, entirely disregarding carefully considered advice, invested a considerable sum of money in the purchase of a large barge which they filled

FIG. 1.—BRAY.—DEEP SCOUR UNDER WALL AND GROYNE.

FIG. 2.—BRAY.—ACCUMULATION OF SAND ALONG SHORE.

FIG. 3.—BRAY.—SAND AND SHINGLE ON LEE SIDE OF GROYNE.

with concrete and sunk in the vicinity of the shingle bank and quite close to high-water mark. Had they wished to aid the sea and destroy their beach they could not have taken a more effectual course. They have indeed done about the worst thing they could have done for that particular shore. The scour around the hulk, in a few weeks, has caused an incursion of high-water mark of 30 ft. on the lee side of the obstruction. The symmetry of the beach is destroyed, and the coming winter will probably see an extensive breach in the immediate neighborhood.

It is a remarkable fact that, while it is usual to secure expert assistance for drainage systems, water-supply systems, road-making, etc., etc., in the case of foreshore protection—a subject of great difficulty and complexity—corporations and private individuals alike are wont to act without advice or in direct opposition to the advice they have received. This sunken barge at Wicklow will have to be removed, and this will probably cost more than was expended in putting it in place. In the somewhat unworthy attempt to get out of paying engineer's fees, etc., this little council of self-constituted experts have run themselves into considerable expense and accelerated the destruction of their beach.

A few more particulars as to actual results may be given here, though the brevity of this paper precludes the possibility of going into many interesting details.

When Mr. Case took the Southwold shore in hand, early in 1898, the waves were constantly breaking down the sheet-piling and the low concrete wall which had been erected for the protection of the rapidly disappearing cliffs. High-water mark was within 41 ft. of the cliff face, and people were deserting their houses, in the full belief that they were no longer safe.

It is instructive to note the gradual and steady improvement which has taken place on this shore since the Case groynes were put down, and Table No. 1 shows concisely the recession of high and low-water marks, and the accumulation of beach, in tons per 100 ft. of coast-line.

Thus it will be seen that this large accumulation of 3 787 tons of material was gathered in, ton by ton, as it were, and that the pushing back of high-water and low-water has been accomplished step by step in a period of 18 months. During the year 1900 the improvement has

been maintained, and the groynes have been raised three times; the land ends of the original groynes having long since disappeared beneath the ever-increasing new shingle bank, the depth of which is between 6 and 7 ft. at its deepest point. The waves of the highest tides no longer reach the toe of the cliffs, and the residents begin to hope that their homes may, after all, escape destruction.

TABLE No. 1.

Recession of the Sea.			Accumulation per 100 ft. on the coast line.
Dates.	Distance to high-water mark.	Distance to low-water mark.	
April, 1898, to Sept., 1898	20 ft.	6 ft.	892 tons.
" " " Oct., "	28 "	15 "	1 412 "
" " " Dec., "	40 "	36 "	2 424 "
" " " Jan., 1899	48 "	49 "	3 187 "
" " " Sept., "	68 "	54 "	3 787 "

The action of these groynes is well shown at Lowestoft. Fig. 1, Plate XXVIII, is a photograph taken on September 25th, 1898. Fig. 2, Plate XXVIII, was taken on January 18th, 1899. In four months all three groynes have been almost covered by the deposit of sand and shingle.

At Mundesley, on the Norfolk coast, the system has been applied very successfully in conjunction with a stepped wall especially adapted to meet the requirements of the groynes. As will be seen by reference to the section, Fig. 1, the major axis of the ellipse terminates in the wall just below the promenade. The wall itself is a comparatively slight structure, but quite strong enough to throw back any surface water which, in exceptionally high tides, may be dashed against it in the form of surf. Here, again, attention is particularly directed to the manner in which the whole shore has improved in section. In October, 1898, high-water mark was practically up to the toe of the existing wall; in 6 months' time it had been driven back nearly 40 ft., and in that same time low-water mark had receded 64 ft. Nearly all the steps of the wall are covered, and there is an accumulation averaging 2 ft. in depth for a distance of nearly 100 ft. Lower down, again, at a distance of 300 ft. from the wall the sand accumulation is more than 3 ft. deep near the wall, and at 361 ft.—which was formerly

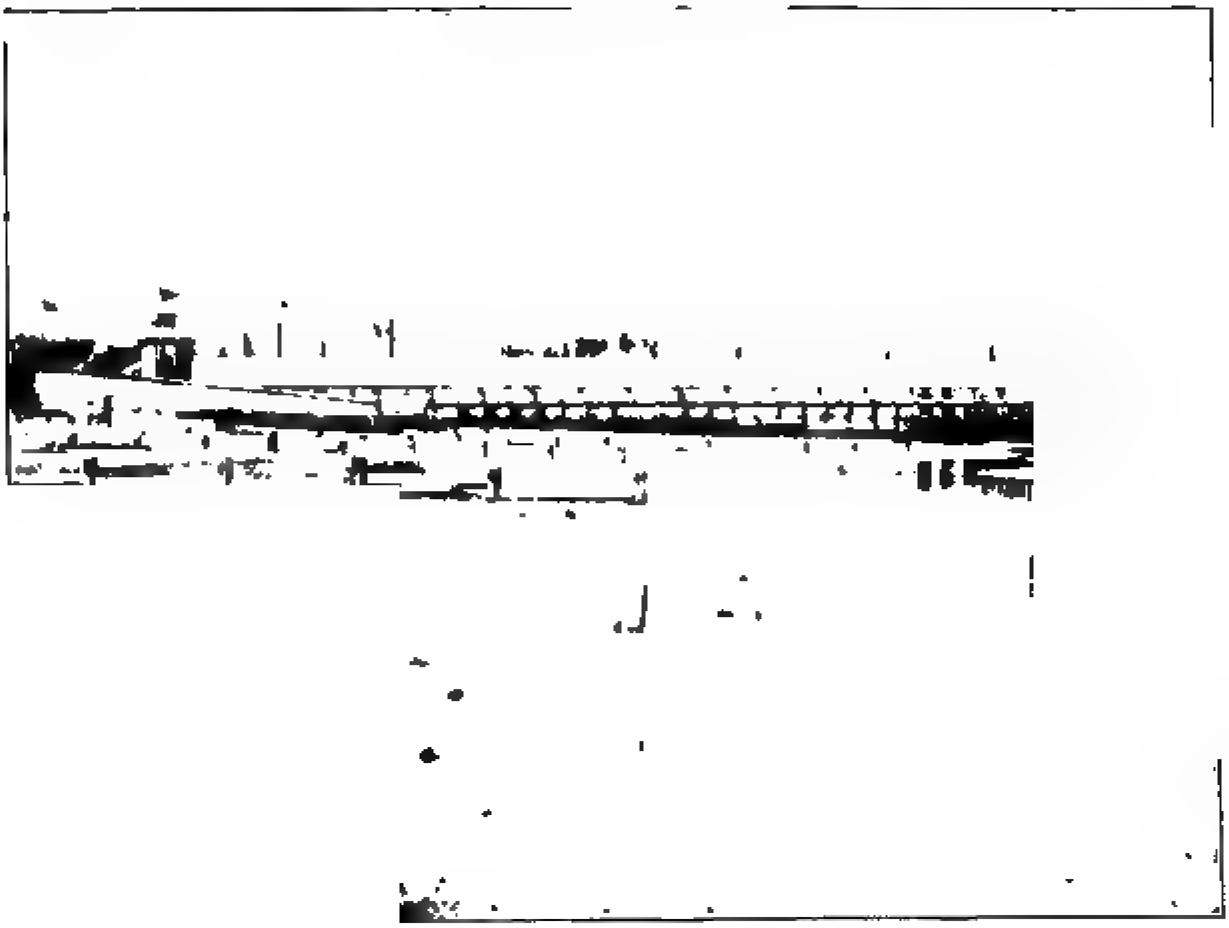


Fig. 1.—Lowestoft, Showing Case Groynes on Sept. 25th, 1898.

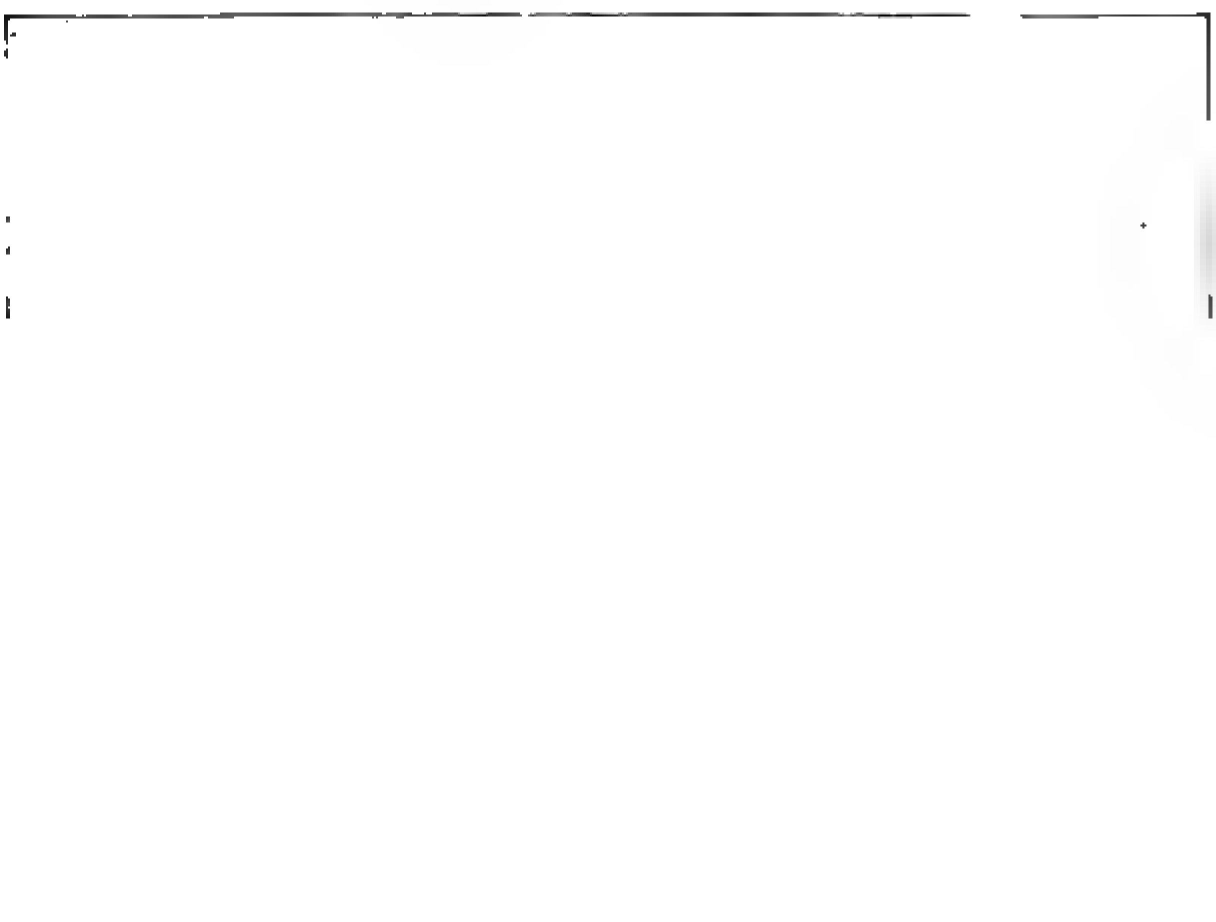


Fig. 2.—Lowestoft, Showing Covering Over Case Groynes on Jan. 18th, 1899.

the distance of low-water mark from the cliff—there is now a deposit of firm, hard sand, 2½ ft. above the present low-water mark, 64 ft. further on. The accumulation in this instance, between October, 1898, and April, 1899, was calculated at 2 846 tons per 100 ft. of coast line.

Attention is here called to the form of the stepped esplanade wall, Fig. 3, designed by the late Mr. Edward Case and his successors, Messrs. Case and Gray. This wall is light and inexpensive, and is peculiarly well adapted for use in conjunction with the Case system of groyning.

SECTION OF WALL RECOMMENDED FOR USE WITH CASE GROYNES
FIG. 3.

At Sheringham and Beeston, also on the Norfolk Coast, are to be found instructive examples of the treatment of three foreshores, lying side by side, two of them having been treated successfully by the Case system, while the third is at present in a neglected and unsatisfactory condition. The foreshore to the west is the property of a private gentleman (Mr. Upcher); then comes the town foreshore, in the middle; and then the Beeston foreshore, to the east. Mr. Upcher's and the Beeston shores have been and are protected by accumulations brought up by the Case groynes, but the town foreshore is unprotected, and the sea is continually encroaching all along the new sea-wall.

In July, 1900, there was a depth of 6 ft. of water at ordinary spring tides opposite the Crown Hotel. Careful observations and measurements show that in a period of 10 months Mr Upcher's foreshore had accumulated 1 050 tons per 100 ft. of frontage, and that of Beeston had, in the same time and over the same frontage, gained to the extent of 1 149 tons. All this time the unprotected portion had gone on wasting away at the rate of about 380 tons per 100 ft. of frontage. It

is also shown that high-water mark has been driven back at Mr. Upcher's and at the Beeston shores, and has as steadily gained on the land opposite the town.

At Cromer, also on the Norfolk Coast (see Figs. 1 and 2, Plate XXIX), remarkable results have followed the application of the system.

Fig. 1, Plate XXIX shows an extensive swale at Cromer on October 29th, 1897; and Fig. 2, Plate XXIX, is a view of the same place taken two months later, showing the obliteration of the swale as a result of the action of groynes.

The deep scour on the lee side of high timber groynes at Cromer and at Overstrand is shown in Figs. 1 and 2, Plate XXX.

It is a strange and regrettable fact that there are still to be found those who persist in upholding and applying worn-out or obsolete systems, long after the superiority of newly discovered methods has been incontestably demonstrated. Even among engineers in the old country there yet exists a tinge of sentiment in which the unreasoning "follow-my-leader" spirit predominates. Oblivious of the fact that the one great aim of their profession is to utilize and guide the forces of Nature to the greatest advantage for the good of mankind, they, with a truly pathetic reverence for the antiquated, continue to work on lines altogether unsuited to modern requirements.

Becoming stereotyped in their ideas, they are prevented from using freely their intelligence, and marching with the times. Their admiration for some old name or some old school blunts and fossilizes their senses to such an extent that they become incapable of learning. Fortunately, such specimens are rare; and their attempt to stand still in a world of advancement can only lead to their being trampled under the feet of the thousands in search of progress and improvement.

With stick-in-the-mud principles we should have no sympathy, and nothing in common. When the superiority of a repeating rifle over a flint-lock, as a weapon of destruction, has been proved, we no longer go to war armed with the latter weapon; nor do we clamor for the rough-and-ready surgery of the Dark Ages when we know we have better science and appliances at hand. Every scientific manipulation of matter which brings increased efficiency at less cost should meet with attention and support; every step in the right direction should be hailed with delight.

It was pointed out in the writer's paper before the Institution of

Fig. 1.—Cromer, Showing Extensive Swale on Oct. 29th, 1897.

Fig. 2.—Cromer, Showing Obliteration of Swale in Two Months.

Civil Engineers of Ireland that, if we turn to a consideration of the actual results produced by high groynes, which engineers have for years past adopted all around these coasts, we will find that, in 99 cases out of 100, scours are caused at the very points which it is necessary to protect. The Hastings and St. Leonards foreshore furnishes an excellent example. It is typical of the high-groyne system. There are deep scours on the lee sides of all the groynes, and the shore, when viewed from the sea, has the appearance of a large saw. Each groyne is a distinct source of weakness to the wall as a whole. The scours to the lee are turned into small deep fiords at high tide, and into these the sea rushes with terrific force whenever there is a storm dead on shore or from the southeast. During such a storm, the wall is attacked at its lowest foundations. On the Hastings shore there is marked scour all along the sea ends of the high groynes, the soft yellow sandstone being exposed and constantly subject to erosion through the sawing action of flint shingle, which is carried laterally along the shore with every tide. In the course of time, this encroachment must reach the line of the esplanade wall many feet below its present foundations, and the expense of underpinning, toe-walls, sheet-piling, etc., will be very heavy. The serious objections to the ordinary high groynes may be summed up as follows: (1) scour close up to wall; (2) scour at or about mean sea level, and general denudation of the shore between mean sea level and low-water mark; (3) danger to children; (4) impossibility of getting along the beach without the exercise of more than ordinary agility in climbing up or down vertical structures of 8 or 10 ft. in height. It is not going too far to say that one or more of these objections apply to nearly every shore in the British Isles where high groynes have been used.

An examination into the causes of breaches in sea-walls has convinced the writer that the mischief is very frequently traceable to the existence of some high groyne in the vicinity of the breach. Corporations continue to vote large sums of money for the erection of costly high groynes of an obsolete pattern, each of which is in itself a distinct menace; and, regardless of the object lessons with which they are surrounded, really add to the cost of maintaining their walls without bringing about any permanent improvement in their foreshores. The Brighton authorities have expended, and are expending, large sums of money on the unsightly high groynes, and it is not going too far to

say that the Brighton shore would be more attractive and more safe had these high groynes never been constructed. The authorities at most seaside places are quite contented to go on spending money, in the happy belief that what was good enough for their predecessors is good enough for them. They have a particular aversion to anything new, and the saving of cost and scientific nature of a discovery seem in themselves to be elements or factors to be regarded with suspicion and disfavor. It is a very long time before Captain Eads could get anything like a hearing when he advanced his scheme for deepening the Mississippi Estuary, and yet the scheme itself was simple and inexpensive, highly scientific, and, as results showed, eminently practical.

The writer has now under his observation several sea-walls where the approach of low-water mark to the foundations has necessitated the addition of toe-walls from time to time, and he can produce abundant evidence to show the damage done by high groynes in such cases, not only near the wall, but at mean sea level, where probably the worst erosion takes place. It would be easy enough to multiply examples of the damage done by high groynes; and the writer will be pleased to furnish actual details with respect to numerous shores, both in England and Ireland, which have been under his close observation for many years past.

The writer regrets that, within the limits of this short paper, it is impossible to discuss even briefly the important questions of traveling material, ocean currents and sub-oceanic deposits, but he ventures to quote a portion of a letter from his pen, which appeared in the *Times* of October 14th, 1899. This letter was written in order to call the serious attention of the authorities to the importance of watching scientifically the coast line all around the British Isles.

"At the present time there is absolutely no official and reliable record of the changes annually taking place round our coasts, and these changes are constantly affecting buildings and other works which have been carried out at a large outlay of public money. Light-houses, coastguard stations, roads, and other necessary structures are maintained chiefly at the national expense, or by county councils and local authorities, and it would, I am sure, be advantageous if annual surveys were taken and returns given which would enable engineers to take the necessary protective steps before any serious damage had occurred. The Admiralty charts are excellent for deep-sea soundings and for the purpose of navigation, but they contain very little information on the question of currents affecting the coast line, and it would require the

PLATE XXX.
PAPERS, AM. SOC. C. E.
AUGUST, 1902.
ALLANSON-WINN ON FORESHORE
PROTECTION.

FIG. 1.—CROMER, SHOWING DEEP SCOUR ON LEE SIDE OF HIGH GROYNE.

FIG. 2.—OVERSTRAND, SHOWING DEEP SCOUR ON LEE SIDE OF HIGH GROYNE.

careful attention of a department to keep a satisfactory record which could be relied upon when the time for action arrived. As matters stand at present, it is, as a rule, only at the eleventh hour, and after considerable damage has been done, that an engineer is called in, and the mischief is then probably so considerable that only a large expenditure of money can save the situation; whereas, had the note of warning been struck a year or two sooner, the catastrophe might have been averted at comparatively trifling cost. Amongst the duties of the suggested department the following may be enumerated: (1) the systematic and repeated taking of sections (over the same lines) on all shores, as well as contours of high-water, low-water, and mean sea-level lines—this latter is very important, as much damage is done during storms taking place at half-tide; (2) the taking of soundings; (3) calculations based on observations respecting the varying rates and directions of currents at high-water and low-water and mean sea-level; (4) observations as to the velocity and *vis viva* of waves; (5) observations on the travel of beach, sand and other material, especially round headlands, piers, breakwaters, and across bays and the estuaries of rivers. As one of the superintending engineers of the late Mr. Edward Case, I had frequent opportunities of discussing the question with this gentleman, whose system of groyning is now so well known and appreciated at many places in England and Ireland, and we invariably came to the conclusion that the whole question should be dealt with as a national one, and that all shores—save alone rockbound coasts, the alteration in which is so slow as to be practically nil—should be closely watched by the State. The Ordnance Survey maps are, of course, admirable, but they only show the changes in high and low-water marks at long intervals of time. What we require is a succession of observations by means of which any mischief may be readily detected, and deal with it in its initial stage, on the 'stitch-in-time' principle. Did space allow, I could multiply examples of instances where acres of valuable land and house property have been lost, an engineer only being called in at the last moment, when some country road, building, or a railway line was in jeopardy. This kind of thing is hardly fair to the profession, and is analogous to calling in a doctor to see a moribund patient. Cases like this would not occur if the State took the matter up; for the competent men in charge of the department would at once give notice on the approach of danger, which might be threatening, not only the immediate foreshore owners, but the owners of low-lying property far inland, and the proportion of cost to be borne by all interested in the necessary works could then be determined. Procrastination—that worst enemy to economy—would be avoided, and everyone would benefit. How such a department should be constituted, and whether it should be under the control of the Admiralty, the Board of Trade, or the Office of Woods and Forests, are questions quite out of my line, but from observation and experience I believe that a large saving in

the future would result from the adoption of some such scheme as I have suggested."

Soon after the appearance of this letter the writer got into communication with the Board of Trade and the Board of Agriculture, and received the following replies:

"7, WHITEHALL GARDENS,
"LONDON, S. W.,
"October 17, 1899.

(Board of Trade, Fisheries and Harbour Department.)

"R. G. ALLANSON-WINN, Esq.

"SIR:

"With reference to your letter of the 4th inst., relative to a suggested establishment of a department to undertake various duties in connection with the protection of the coast of this country against erosion by the action of the sea, I am directed by the Board of Trade to inform you that it appears to the Board that the proposal, if carried out, would entail very considerable expense, and would probably necessitate the revision of many Acts of Parliament under which the coasts are now protected. In all the circumstances of the case the Board of Trade are disposed to think that the scheme is not feasible at present.

"I am, Sir,
"Your obedient servant,
"T. H. W. PELHAM."

"BOARD OF AGRICULTURE,
"3, ST. JAMES' SQUARE,
"LONDON, S. W.,
"January 6, 1900.

"R. G. ALLANSON-WINN, Esq.

"SIR:

"I am directed by the Board of Agriculture to advert to your letter of the 9th ult., and to say that the Board have read your communication with much interest. The only portion of the work which you propose should be undertaken by the Government which it would be practicable to entrust to the Ordnance Survey is that which relates to the systematic and repeated taking of sections and contours of all shores subjected to change, and the Board do not think that it is at all probable that the Treasury would feel justified in providing at the public cost for the considerable expenditure requisite for the purpose. The Board might, however, suggest that your proposals might be brought under the notice of their lordships and the Admiralty.

"I am, Sir,
"Your obedient servant,
"P. G. CRAIGIE,
"Assistant Secretary."

The serious disturbance in South Africa then commenced, and, with public attention so much absorbed in the war, it was out of the question to worry Government departments with a matter of such secondary importance.

It must be admitted that in Germany the State sets a good example by encouraging such work as that now being carried on by Professor Engels at the *Flussbau Laboratorium* in Dresden. One would think that the wearing away of their native shores should be as important to English, Irish and Scotchmen as the changing of the course of the Elbe, the Rhine or the Spree can be to the Germans. However this may be, in the Dresden Technical School the fullest encouragement is afforded to scientific discoveries and experiments. Models of important rivers are made, and the professor and his assistants are enabled, by the introduction of different colored sands and the regulation of the water supply, to arrive at a very fair idea of what may happen in floods and droughts, where banks are likely to be scoured away and where material is likely to accumulate. Contours of the channels and shore lines of many of the great German rivers have been laid down with accuracy, and Professor Engels has been able to copy in his models all the breakwaters, curves and embankments. The idea is that, by testing certain alterations, such as building dams, reclaiming lands, etc., in the model, engineers may be placed on their guard, and so avoid doing what may lead to useless expenditure. All this shows how keenly the German Government is alive to the desirability of improving—without unduly interfering with the rights of individuals—the general condition of the country.

The gleaming cliffs and yellow sands of Great Britain receive no such attention. It is only when some public road or wall, or some railway line, is attacked that attention is drawn to what the sea is doing, and it is then very often too late to take protective steps, except at great cost. The sea requires constant watching; and the writer contends that if this watching were carried out properly and scientifically, engineers would not find themselves so often taken by surprise, there would be fewer bad cases of erosion, and a considerable acreage might be annually saved.

An inspection of certain shores in the neighborhood of New York City and in New Jersey has convinced the writer that there is a very large travel of material along the coast line, and, from reports re-

ceived, he is inclined to believe that this is the case all the way down the eastern shores of the United States. There is plenty of carrying power in the Atlantic, and, the occurrence of rough weather being favorable to the rapid action of low groynes, there can be little doubt that the Case system would succeed wherever correctly applied for the protection and improvement of those shores.

Vol. XXVIII. AUGUST, 1902. No. 6.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

SEPARATE *VERSUS* GENERAL CONTRACTS.

An Informal Discussion at the Annual Convention, May 21st, 1902.*

SUBJECT FOR DISCUSSION.

"In contract work, either public or private, is it preferable to make separate contracts for the different branches of trades involved, or to combine all under one general contract?"

By Messrs. GEORGE E. GIFFORD, T. CHALKLEY HATTON, CHARLES G. DARRACH, S. BENT RUSSELL, M. WARD EASBY, CHARLES WORTHINGTON and HORACE ANDREWS.

GEORGE E. GIFFORD, M. Am. Soc. C. E.—The topic under discussion will be regarded by the speaker primarily from the standpoint of the contractor, and by giving the views of the contractor, he hopes to show the owner, the purchaser, or the consulting engineer, that his own interests lie with the contractor in this matter. He believes that contractors almost universally will agree that the dividing up of contract work, so that each principal branch is under original contract with the purchaser, is preferable to the making of one general contract which must be sublet to specialists in the different trades. Mr. Gifford.

The speaker has talked with many contractors on this subject, and

* The discussion of this subject, for which no formal paper was presented, is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion. (See Rules for Publication, *Proceedings*, vol. xxv, p. 71.)

Communications on this subject received prior to September 26th, 1902, will be published subsequently.

Mr. Gifford. does not recollect ever hearing one say that he preferred the general contract system. It is recognized, of course, that there have been formed large contracting firms and corporations who are ready to undertake work of almost any magnitude, and involving many different trades. This has been brought about not so much from preference as from necessity, because the greater part of government and municipal work is being let in this way, and, in order to bid upon it at all, the contractor must take it as a whole. This is also true of some private work, especially the large building constructions.

In many cases the contracting firm consists simply of an office; practically all its actual operations are performed by sub-contractors, and the most important man in the whole outfit is the purchasing agent. He does what the consulting engineer or the architect should do at first hand for his clients. In other cases the contracting firm makes a specialty of some particular branch of work, we will say mason-work or steel-work, and actually carries out this portion of the contract with his own appliances or at his own shops. The remainder, which he cannot do himself, he is obliged to sublet or "farm out," as it is called, or else undertake operations with which he is not familiar and which he can only carry out at a disadvantage. He would much prefer to have only such work as he himself can perform, but is obliged to take the remainder in order to get his portion. The consequence is he is loaded up with a lot of work which he is not adapted to perform, but for which he has to be financially responsible, and he either does it at a loss to himself or at a loss to the purchaser.

It may be urged that the proper way to overcome this difficulty is by a combination of contractors in different lines who are willing to unite their bids in a grand total, including only one profit, and each one then perform his portion of the work. This is no doubt what the purchaser, the engineer, or the architect thinks will be done when he receives proposals in this way. The only trouble with this theory is that it does not harmonize with practice. There is not an entire unanimity of opinion and complete trust in one another among contractors in different trades, which is no doubt to be regretted, but which fact, nevertheless, remains. In a community-of-interest contract someone has to be the principal; someone must be designated as the main contractor, must receive the instructions, confer with the owner or his agents, draw the pay and settle with the others. There is the rub.

What is the practical way in which general contract work is actually taken?

We will assume our contract to be a large city bridge, involving substructure, possibly with pneumatic foundations, dredging, cut-stone masonry, concrete, excavation, embankment, paving, sidewalks, perhaps some sewers to be extended or moved, and water pipes to be changed. Then we have the superstructure with a draw span which will involve

not only the structural steel, but various kinds of machinery, electric motors, electric lighting plant, a little carpenter work, some automatic gates, fancy hand railing, asphalt paving, and painting. There have been bridges let in New York City the bidding sheet of which showed more than one hundred items for which prices had to be inserted. Mr. Gifford.

We will assume further that the substructure and the superstructure (it being unnecessary to designate specifically before this Society just what items are included under the above heads) are approximately equal. The bridge builder, for example, begins to prepare his bid and finds that he must either combine with some other contractor who will take care of all parts of the work which are technically known as substructure or general contract work; or he must get prices on the separate items from tradesmen of all branches; or he may assume that he knows enough about work of this kind to make his own figures for everything.

The chances are that the first mentioned alternative will be met with the statement: "We will make you figures for our part of the work provided you will agree to tie up with us." This may be the most satisfactory way in the end, provided the bid is successful; if not, there follow the usual charges, expressed or implied, that the bidder was "thrown down" by a bid too high, and if he is the successful bidder and finds that other figures, better than those given to him, have been submitted, he regrets his inability to deal with a cheaper party.

This plan also presupposes absolute confidence between the parties to the proposal, as to fair dealing all around, and this does not always follow. Many of the largest contractors and steel workers absolutely refuse to make prices to other contractors in advance of the receipt of the contract; and in some cases will even decline to bid to another contractor, even though he holds the contract; the position of sub-contractor being so undesirable, for many reasons, particularly the inability to deal directly with the owner, and the financial delays and losses involved in case the main contractor is slow pay or becomes financially embarrassed. The speaker knows what he is saying, in making these statements, from the fact that the firm which he represents almost invariably declines to assume the position of sub-contractor on any work He knows of others who feel the same way.

Returning to the second method of preparing a proposal, that of getting separate prices on all the different classes of work, we find a marked disinclination, on the part of dealers and tradesmen, to give their best figures for bidding purposes, if they will give them at all. An inquiry of the sort is likely to be met with the question: "Have you this contract?" The answer being "No," it is likely that an excuse will be offered, such as "too busy to figure just now," or else the statement: "We will give you a safe price with which to bid; but, in

Mr. Gifford. case you secure the contract, we may be able to do better, and expect to hear from you again." Is this likely to be satisfactory to the bidder desiring to make a close bid? And after he had added his 5%, 10%, or whatever he sees fit to cover the financing of the job, contingencies, and his profit, is it likely to be an economical method for the purchaser?

No doubt, if every contractor had the skill, and knowledge of costs and conditions to make up his own figures for all classes of work, it might be best to make a general contract. Sometimes he attempts to do this, with the result that he is entirely too liberal in his estimate, and loses the work, or else makes a mistake somewhere, and, when he comes to do the work or purchase his supplies, finds that there is a corner against him, or some condition has arisen in the market or in labor which he has not accounted for. It is practically impossible for one man or one firm to be fully posted on all the branches of work entering into a large bridge or building contract. The consequence is he finds that he has a losing contract, a highly undesirable state of affairs, not only for himself, but for the purchaser. There is probably no engineer or owner who desires to see his contractor lose money; it is certainly bad for the contractor, and a source of great trouble to the purchaser, if not an actual detriment to the work. Of course, it is not right to assume that all contracts will be profitable, even if taken and prosecuted by specialists; all are likely to make mistakes; but it is fair to presume that fewer mistakes are made in one's own line of work than in something with which one is not familiar.

The subject has thus far been considered principally from the standpoint of the contractor, and the speaker has endeavored to show wherein it would benefit the contractor to take only his own kind of work. In order to bring this about it must be shown to the purchaser, or the engineer or architect who represents him, that he will benefit by dealing separately. The principal argument offered in support of the general contract system is the supposed advantage of having only one party to deal with, and the presumption that trouble among independent contractors on the same work will be avoided by having them all under one control. The first proposition practically includes the second, and, while it may avoid some clerical or office work, it surely does not avoid anything in superintendence or inspection; and the fact that the combining of a large contract under one head will eliminate a large amount of competition would seem to far outweigh a slight saving of detail in drawing up a few extra contracts or making a few extra vouchers for payment.

It is a fact that the general-contract method eliminates competition. As an example, may be quoted the bridge work for the State of New York. The bulk of this work consists of not very large bridges

over the canals, some of them aggregating perhaps $50 000, but most of them much less. It is the invariable practice in the Department of Public Works to make one contract to cover each structure, and they nearly all involve a little concrete, a little excavation, a little embankment, and so on, together with the steel superstructure, which, in the case of lift-bridges, may be quite complicated. The consequence is that there is little or no competition in this State work, and in case they are so fortunate as to receive two or three bids, about half the time the bids exceed the appropriation, because excessive prices are put in for the little odds and ends of work which the bridge builder does not want, but has to take in order to get the steel-work. Mr. Gifford.

A local contractor, knowing or being able to ascertain easily the conditions prevailing, could take care of these items well and economically, but he is practically debarred from bidding because he cannot bid on the bridge and cannot find any bridge company who will give him a price. The bridge companies, on the other hand, at least a good many of them, not wishing to be bothered with the substructure work, especially under present conditions, when there is plenty of more desirable work, do not prepare any estimate, and the result is as stated; there is practically no competition and the prices are excessive.

There is no doubt whatever that much better results would be obtained if this work could be divided into, perhaps, not more than two separate contracts. The speaker once took occasion to ask an official of the State why they adhered to this practice, and found that it is because when the laws making the appropriations are passed, they direct that such and such moneys be appropriated and "a contract" be entered into for the work. The officials feel that they are bound to adhere rigidly to the letter of the law. It seems to be nobody's business to change this form of wording. This is only a typical case. The speaker could quote many instances where, of his own knowledge, the method of combining different kinds of work under one contract has prevented competition and raised the cost.

It seems strange that among the chief adherents to this method is the United States, in its various departments, and the largest municipalities of the country. We scarcely ever find it among the railroad companies, who regard the economical aspect more carefully than public officials. The Navy Department, for example, in letting the contract for a building, will include all masonry, carpentry, steel-work, plumbing, etc., under one contract. This surely precludes a certain amount of competition, and presumably is an expensive method, for the reasons stated above. Some of the principal bridge companies have practically turned down Navy Department work, although quite desirable in itself; but it cannot be secured without taking much work which is not desirable, or else under a sub-contract, with its attendant disagreeable features.

Mr. Gifford. The same comment applies to the Treasury Department work, let by the Supervising Architect. Not long ago an officer of one of the large bridge companies wrote to the speaker, as follows:

"The National Association of Metal Work Manufacturers has been for months at work on the Government to get them to separate steel and iron-work from general contracts for public buildings, and believe they are about to succeed."

The speaker hopes they may succeed, but has not yet been informed that they have done so.

Within the last few months the speaker received the following inquiry, in a letter from the engineer of one of the largest bridge structures now in progress in this country:

"Do you prefer bidding on substructure and superstructure together, in one contract, or bidding on the superstructure alone? What are your controlling reasons therefor? It is assumed in this question that the cost of substructure is not less than one-third of the entire contract."

To which the speaker replied as follows:

"We prefer bidding on the superstructure alone, making the substructure contract an independent one, to be handled by other parties, presumably those in that special line of work. As to our reasons, the general statement that we are in the bridge business only, and understand it only, would seem to make any other reason unnecessary. The employment of sub-contractors is frequently a nuisance, and always undesirable to us."

The speaker was afterward informed by this engineer that several other prospective bidders had answered in a similar manner.

A letter* by Edgar A. Rossiter, Engineer, Department of Track Elevation, Chicago, Ill., states:

"In regard to the discussion over the new Genesee Ave. bridge at Saginaw, Mich., would state. * * * Bids should be asked on the substructure and superstructure separately, and then many reputable companies would be glad to submit detail plans of superstructure, as it would be right in line with their work and they can do so without excessive expense. There are many bridge firms who can obtain all the work they desire at the present time in superstructure alone, and do not care to figure on substructure, others will not figure where the substructure and general conditions existing are an unknown quantity; all these features reduce the number of bidders to a few, and then the lowest figure is based on a guess or inside knowledge of the facts. * * * "

Following up this line, the speaker took occasion to write to a contractor, who, he had reason to think, had probably bid on this Saginaw job. This is his reply, and it bears out the speaker's contention so fully that it is quoted in full:

"Replying to your favor asking our opinion as to the advisability of making separate contracts for different branches or trades involved

* *Engineering News*, February 13th, 1902.

in bridge work, will say that we think it is decidedly advantageous to the purchaser to let the contracts for the different trades separately; steel superstructure in one contract, masonry or concrete work in another. Mr. Gifford.

"It is a fact that we frequently refuse to bid upon work for the reason that we would have to bid upon masonry as well as superstructure. In cases where we do bid on the entire job complete, we always intend to bid safe and high enough on the substructure so we can turn around and sublet it to men who are engaged in that line of work. We think there is no question but what, as a rule, money can be saved the purchaser if contracts are let separately.

"At the Saginaw, Mich., letting, which you refer to, will say that the substructure and superstructure were combined, and parties had to bid on the entire work. At the first letting we refused to bid upon the work, but did bid at the second or re-advertised letting."

These quotations show that this subject is being considered by others, as well as contractors, and if the present common practice of making blanket contracts, particularly on public work, which the speaker believes to be radically wrong for all parties concerned, could be reformed by those in charge of the letting of contract work, the speaker feels that it would be a benefit, not only to all contractors, but to the public.

T. Chalkley Hatton, M. Am. Soc. C. E.—The speaker looks upon this question from the standpoint of the municipality, or his client, and the result of his experience has clearly indicated that work can be done much better and more cheaply by letting it out under separate contracts, each representing the different branches of the trade, than under one general contract. It is true that where this method is followed, one contractor is constantly interfering with the work of another, and this interference often results in claims for extra time or remuneration, but the speaker has never experienced any trouble in settling such disputes with satisfaction to the several parties interested, and without any extra cost to his clients. Mr. Hatton.

In the construction of a system of sewers the speaker has been able to save from 5 to 10% of the cost of a general contract by having the municipality furnish the several materials, such as bricks, cement, pipe and castings, letting out the labor only to a contractor. In one of the cities for which the speaker has for a number of years been engaged as engineer, the street paving has of late years been performed by letting out the labor to a general contractor, the city purchasing the paving metal and foundation materials.

In the construction of water-works and electric-power plants, with which the speaker has been connected within the last five years, the contracts have been divided up, so as to represent the several branches of the trade, with the result of better and cheaper work; and it seems

Mr. Hatton. reasonable to look for such a result, first, as to cheapness, in that the bidder in estimating the work, certainly adds a certain percentage of the cost of his material as a legitimate part of his profits; second, as to better work, in that the engineer deals directly with the manufacturer, and can thus control the class of material far better than if he must deal through a contractor who looks upon the question only from the side of expense.

It may be said that, the municipality or corporation being in the market but seldom for materials of certain classes, the manufacturer will not cut his prices as close as though he were dealing with a contractor who is his constant customer. In reply to this it might be said that when dealing with the contractor the manufacturer is not always sure of his money; whereas, when dealing with the municipality or corporation his money is assured upon completion of his contract, and thus he can afford to sell quite as cheaply; and besides, the engineer, if he understands his business, should be quite familiar with the prices of the several products which comprise any engineering work which he is called upon to design, and can thus protect his client.

The speaker cannot agree with Mr. Gifford regarding the contractor preferring to have the work divided into different contracts, as it has been his experience that more competition in bidding has resulted in letting the work out as one general contract, as the contractor has a better chance of making up his loss from one branch of the trade by his gains upon another. The speaker thinks that the best scheme, all around, if the engineer can have the confidence of his client and the manufacturer as well, is to go into the open market and purchase the various appliances comprising the work. He can do this, particularly in the electrical field, under his own name, and do it at the same price that the agent or middleman gets, and thus save his client the commission. This has been done by the speaker for the past two years in corporation work with a saving of from 3 to 8 per cent. In public work, however, this method would be a difficult one to follow, as it at once arouses the suspicion that the engineer is getting a commission; and besides, the usual laws provide that all public work shall be advertised and let to the lowest responsible bidder. It is true that dividing up the work into separate contracts adds very much to the burden of the engineer, but if the engineer is not desirous of assuming this extra burden he should not undertake the superintendency of such work.

Mr. Darrach. CHARLES G. DARRACH, M. Am. Soc. C. E.—The speaker, judging by his experience of 35 years, would answer this question in the affirmative, except in cases where the engineer or architect can select an expert general contractor. The work certainly can be constructed at less cost if the various items are separated, and the work of

generalization devolves upon the engineer of construction. Better work can also be obtained under such circumstances. Mr. Darrach.

The unfortunate part of the proposition is that the owners, and employers of the architect and engineer, have the idea that that work for which they are willing to pay the general contractor a handsome remuneration should be done by the architect and engineer for practically nothing. The vexed question of unbalanced bids would be eliminated, and the owner would be positively certain that he got what was specified.

The present pernicious habit of architects in letting the work for the mechanical installation for public and private buildings to the general contractor (who knows as much of the subject as the unborn babe, and is about as responsible) cannot be too strongly condemned. The speaker expresses himself with some degree of feeling in this matter, as a piece of work which he designed, costing more than $125 000, was given to the tender mercies of a general contractor, and the speaker's supervision of the work withdrawn. The natural result of this was bad work, heart-burnings, law suits, and all the attendant evils.

S. Bent Russell, M. Am. Soc. C. E.—There are contracts of a certain class, with which engineers have to do, that require special treatment, and which may well be mentioned in discussing this question, although, in view of the previous discussions, it may seem almost like changing the subject. The speaker refers to machinery contracts, such as for steam-engines, for boilers and furnaces, for blowing engines, pumping engines, dynamos, mechanical filter plants, floating dredges or other machinery. In such contracts it is frequently, if not usually, the case that the contractor is the manufacturer of a certain class of machines. Mr. Russell.

For example, the contractor is a builder of pumping engines. His whole attention is given to building pumping engines which will be a commercial success. In such a case there should be no middle men between the builder of the pumping engine and the owner or user of the machine. The builder and the user should be in as close connection as possible. This rule should be observed, not only for the good of the parties to the contract, but also for the good of the general public, in the long run, because the advancement of the art of building pumping engines will thus be favored.

The builder of the pumping engine must know how the engine operates in service in order that he may see best where improvements can be made.

It has been only too often the case that builders of machines could not get accurate information as to the actual operation of their products. If the user of the machine is making a commercial success with it, he does not stop to make efficiency tests or scientific observations.

Mr. Russell. In most cases, the machine builder can more easily obtain knowledge from the machine user where the two are dealing with each other directly and without intermediaries.

May it not be said then: First, that, where the work is to be done by the builder of a special class of machinery, there should be as few middle men as possible; and, secondly, that one good reason for this is that the machine builder may the better obtain accurate information as to the success of his work in all its details, and thus the greatest advancement of the art be obtained.

Mr. Easby. M. WARD EASBY, M. Am. Soc. C. E.—There seems to be one aspect of this matter which has not been touched on, and that is, the view most owners take. Prospective owners who desire their work executed by contract are always anxious to know the lump sum for which it can surely be done, and this the general contractor guarantees, after a manner; in fact, he furnishes a definite figure.

Even if the owners feel apprehensive about extras, they do not seem to fear them as much as an estimate made from scheduling all the bids of the sub-contractors.

The fact that the general contractor accepts the responsibility of making a complete structure or plant, and thus relieves the owners of expense in making the work of the various sub-contractors come together, is what makes his position so strong.

An instance has been given of a mechanical plant, of some 1 200 H.-P., in which the engineer had no extras, although he let out all the work by sub-contracts; but it is not stated that it is even the general experience of this engineer, that, under such circumstances, no extras occur; and it may be said that few are so far-seeing or perfect that they can prepare specifications which will draw the lines of definition between the work of the various crafts so that all will come together as a harmonious whole, without causing some differences, and consequent charges for extras. It may also be said that few general contractors expect to handle their contracts in such a manner that the cost to them will be no more than the sum of their various sub-contracts.

It may be that the engineer will feel that his specifications are sufficiently clear on any point in doubt, and he may take refuge behind some blanket clause stating that he is to be sole judge in cases of doubt, and thus compel a sub-contractor either to show open fight or do the work for the sake of harmony; but, frequently, the speaker has known a general contractor to pay an extra to a sub-contractor, because it was necessary for the completion of the general contract that some unforeseen work should be done; and, in such a case, if there were no general contractor, either the owners would pay the extra or the engineer would compel some unfortunate sub-contractor to do the work or have an open rupture, which the sub-contractor could not well afford.

There are many such engineers and architects, and though, by their foresight and ability, they seem to save the owners from paying for extras, yet they soon become known to the trades, and the bids of the sub-contractors are correspondingly high. Mr. Easby.

Almost every general contractor is his own sub-contractor for one craft, as, in the case of large buildings, he is a carpenter or a mason; or, for a bridge, the general contractor will be a company which manufactures the superstructure only; but, would anyone expect such a general contractor to make no allowance for the contingencies that will arise, due to the various sub-contractors not making their work come together so that there will be no hitch?

It is a fact that, to make everything run smoothly on a large contract, a general contractor must be an executive of the highest order, and the engineer who expects to let all work by sub-contracts is adding to his purely technical duties those of the general contractor; and, as the general contractor inserts in his estimate items for the cost of his management and contingencies above referred to, the engineer should also be allowed to insert in his estimate, or schedule of sub-contracts, the same items. He should also be allowed extra compensation, to at least the extent of a portion, if not all, of the profit the general contractor would make.

Owners will look with doubt upon such items as charges for executive management and contingencies, and for the latter will rather think the engineer should be so proficient that there should be none; yet, in the case of the lump-sum bid of a general contractor, these items form a part. The owners, however, do not see the estimate in detail, and, not seeing such items, they are not called to their attention, and so they accept the lump-sum bid, trusting to their engineer to protect their interests.

In lump-sum bids the general contractor, under the stress of competition, strives to his utmost to get sub-contractors to shade as close as possible to the specifications, both in quality and quantity, and, to quote a victim of this system, "you get the least the worst man can do."

The system of letting work by general contract is founded largely on the fact that the designing and supervising engineer or architect is ignorant of how to execute his design; and, though he may know how it should be executed, he has little or no knowledge of how to go about it, and so the general contractor, who most frequently does not know how to design, but has plenty of assurance, steps in and relieves the engineer of the responsibility.

Engineers, in letting work by sub-contracts, should be allowed all the items of expense which the general contractors find necessary. In such cases, also, the owners are more at liberty to select their sub-contractors, and need not take the lowest one, in any particular class

Mr. Easby. of work, if they and the engineer consider it to be unwise. The control of the work, in case of changes (especially where less is to be done than originally contemplated), is more to the advantage of the owners in the case of letting by sub-contracts.

Work let by sub-contracts is not so likely to be done for less than by general contract, but the class of work is likely to be infinitely superior, and it is along this line that it seems best to urge the adoption of the system, which should have the support of all engineers.

Mr. Worthington. CHARLES WORTHINGTON, M. Am. Soc. C. E.—The speaker has never been able to see just why contracts for construction, made up of different and distinct classes of work, should be let as a whole, instead of being divided up into logical subdivisions and let as a number of separate contracts, excepting that it lightens the work of the engineer and permits him to shift the responsibility, for the work coming together properly, from himself, where it belongs, to the contractor.

There are a great many small contractors who are expert in their own line of work, but who know little about any other, whereas there are comparatively few who are experts in all classes of work. As Mr. Gifford has said, the bridge manufacturer cannot be expected to know all the details of masonry construction, and this holds equally true in many other cases. Now, if the contract is let as a whole, the former class is practically barred out, and competition is lessened to this extent; whereas, if bids are asked on the work properly subdivided and with each subdivision clearly defined, a maximum of competition will be assured, for each bidder will be thoroughly familiar with the particular work on which he is asked to give prices, and consequently will quote his best figure with a minimum percentage added as a factor of ignorance.

The engineer's place is that of intermediary between the purchaser and various contractors, and his duty to the former requires him to see that the most experienced workmen are employed on the several classes of construction, and that the total cost be kept at a minimum. The purchaser generally knows little about the cost and less about the work itself. For the best results, the engineer should be thoroughly familiar with both, and the contractors should be experts in their several branches. The engineer's plans and specifications should show clearly and completely every feature of construction, so that the several contractors may know exactly what they are bidding on, and so that possibilities of misunderstandings after contracts have been let be reduced to a minimum. Frequently, the engineer is allowed so little time in which to make his plans that this is not possible, in which case, of course, he must use his best judgment to make final results come out satisfactorily; and, under these conditions, the speaker advocates letting contracts on the basis of unit prices for the various classes of work covered by the contract.

Mr. Andrews.

Horace Andrews, M. Am. Soc. C. E.—Although the discussion thus far appears to be all in favor of the subdivision of contracts, there are reasons that may be urged in support of the opposite course.

The dependence between the different branches must often make it more desirable for one person to have the whole work under his control, even if some of its subdivisions are outside of his specialty and must be sublet to those better qualified for their execution.

This month, a large contract was let in Troy, N. Y., where the work was subdivided by the engineer into two contracts. The bidders who were the lowest for the work as a whole made the stipulation that they should have both branches of the work or none. They thought the relationship of the separate parts of the work was so close that the main contract could not be handled profitably or satisfactorily without control of the other. Nevertheless, the work has been let under two contracts, other persons being willing to assume the greater risks.

Although it may often be to an employer's pecuniary interest to subdivide a contract into parts, each of which can be handled by a contractor specially qualified and properly equipped for its performance, still the subdivision of the work entails so great a possibility of conflict between the various contractors, so many opportunities arise for claims and concessions on account of remissness of some of the contractors, that it may be to the real interest of the employer to have dealings with one responsible contractor for the whole work, even at a slight pecuniary loss.

Lawmakers are disposed to ignore a contractor's technical qualifications, provided he is pecuniarily responsible, regarding it to be the duty of the engineer to enforce all requirements of the specifications, until the financial ruin of an incompetent contractor throws the completion of the work upon his unfortunate bondsmen. In such an event there is often less chance of loss to the employer from an attempt to compel responsible bondsmen of one general contractor to complete the work than from combating claims of numerous contractors executing separate branches of the work. Such contractors, on a subdivided piece of work, could reasonably claim to be damaged by delays occasioned by the suspension of work upon the execution of which the completion of their own depended.

Considerations of this nature may have influenced the framers of the law to which Mr. Gifford refers, whereby the Superintendent of Public Works of the State of New York is prevented from subdividing certain State contracts.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

UNIT COSTS OF WORK IN PROGRESS.

An Informal Discussion at the Annual Convention, May 21st, 1902.*

SUBJECT FOR DISCUSSION.

"Is it possible and desirable to keep accounts of cost of work in such a manner as to ascertain unit costs on each class of work?"

By Messrs. S. WHINERY, CHARLES S. CHURCHILL, T. CHALKLEY HATTON, OBERLIN SMITH, CHARLES WORTHINGTON, FOSTER CROWELL and CHARLES G. DARRACH.

Mr. Whinery. S. WHINERY, M. Am. Soc. C. E. (by letter).—Two questions are embraced in this topic: The first relates to the possibility and the second to the desirability of account-keeping intended to disclose the unit cost of work.

The first of these questions has been practically answered by actual experience. Except possibly in some cases where abnormal conditions prevail, it is entirely possible to keep accounts which will show correctly the unit cost of any work, whether that work be in the nature of surveys or other preparatory operations, or of the construction of engineering structures, or of manufacturing. Such accounts are now, not only common, but almost universal, in all well managed enterprises.

* The discussion of this subject, for which no formal paper was presented, is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion. (See Rules for Publication, *Proceedings*, vol. xxv, p. 71.)

Communications on this subject received prior to September 26th, 1902, will be published subsequently.

They differ in scope, detail and accuracy, it is true, but the cases are very few where something of this kind is not attempted and carried out with more or less success, among modern enterprising business men. Mr. Whinery.

Like all other forms of accounting, the value of the results attained will depend upon the adequateness of the general plan and details of the scheme of accounts adopted, the fidelity and accuracy with which the original records are made, and the ability and skill with which these records are compiled and deductions made therefrom.

Each of these three subdivisions of the work is of equal importance, and if either is defective, or neglected, the results attained will be unsatisfactory or entirely worthless. To devise a scheme for a cost-keeping account, with all its necessary details, and to prepare full instructions for its operation, is by no means a simple thing, requiring as it does a very intimate knowledge of the method of conducting the particular kind of work on hand. The difficulty increases with the complexity of the work and the number of unit cost items it is considered necessary to ascertain. It is only after one has had an extensive experience on similar work that one can frame a scheme that will be workable and efficient. It must be simple and easily understood; otherwise the employees who must be depended upon to make the original records will get them hopelessly confused; or a disproportionate amount of time and labor will be consumed in making them. It must be explicit in its details and instructions, for the same reason, and it should be so comprehensive as to disclose where every item of money or labor has been expended. But however perfect a cost-keeping scheme may be devised, it will prove worse than useless if not intelligently and implicitly adhered to by those whose duty it is to make the original entries or records. Every cent expended upon the work, whether in the form of cash or labor, must be accounted for and charged to its appropriate item. This sounds simple enough, but only those who have had exasperating experience with the stupid or negligent employee can appreciate how difficult it is to have these original records properly made. Assuming a good system of accounts and accurate original records, their value will depend upon the care and fidelity with which the original information is compiled and made available for use. In the press of other office duties this part of the work is often neglected or postponed until such a mass of it accumulates that it is then abandoned, or it gets into such a state of confusion that it is difficult or impossible to disentangle and tabulate it, and it is then thrown aside as worthless, with the statement that the problem of determining unit cost is hopeless.

It may be confidently asserted that, with the same amount of care and accounting skill necessary and usual in a first-class mercantile

Mr. Whinery. establishment, it is possible to determine with accuracy the unit cost of any engineering work.

A knowledge of the unit cost of work is of value in many ways, and accounts which enable us to ascertain it are therefore desirable. To the engineer engaged in designing modern work the important problem is how to accomplish the object sought with the least expenditure of money. Other things being equal, that particular detail will be used which is the cheapest. In order to determine which is the cheaper of two details the unit cost of each must be known. The engineer, therefore, finds it important to accumulate the largest possible fund of cost prices. To the contractor or the manufacturer the question of desirability is synonymous with the question "will it pay," and among the more enterprising and intelligent there can be but one answer. The question of success or failure in these times of sharp competition and low prices may depend upon the accuracy with which cost has been estimated, and this again will depend upon the knowledge of unit cost under the conditions that are to be met. These conditions vary greatly upon different pieces of work, and in different localities, and the estimator needs the accumulated knowledge that comes from habitual cost-keeping. It is important, therefore, that this branch of accounting should never be neglected on engineering work. Furthermore, it is important during the progress of any extensive work. The contractor or the manufacturer who has before him at the end of each week the unit cost of his work during that week, can know whether it is being done with proper economy, and, if it is not, he can ascertain the cause and apply the remedy at once, and thus prevent accumulated losses. Accurate accounts will often disclose defective management which may not be detected by personal observation, during the progress of work.

A careful study and analysis of unit cost will enable those interested to devise improvements and apply economies that would otherwise not be thought of.

There can be but little doubt that the notable success of American manufacturers in competing with those of foreign countries is the result of careful attention to the unit cost of details, and has been made possible by the careful and accurate cost-keeping accounts now found in every enterprising shop.

Both questions embraced in the topic, therefore, may be answered in the affirmative.

Mr. Churchill. CHARLES S. CHURCHILL, M. Am. Soc. C. E.—Inasmuch as Engineering is the power of producing the greatest and most permanent results for the least ultimate cost, even the intimation that actual and detailed costs cannot be determined and kept is a stroke against the foundation of the profession.

The keeping of and knowledge of these detailed costs and ultimate values really constitute the greatest care of the successful engineer,

and the proper use of this information is of almost equal importance. Mr. Churchill.

To be told that a certain piece of first-class ashlar masonry cost $6.50 per cubic yard may attract attention; but this fact is not of much value unless we know, further, how this cost is made up, as it consists of the price of the stone delivered at $2.35, and labor on the same, with other materials, aggregating $4.15.

But we are still not at the bottom, because the cost of cutting different stones varies, and the other materials also vary in cost. Therefore our information is not complete until we know that the amount, $4.15, is made up of cutting, $1.14; laying, $2.26; cement, 20 cents; sand, 7 cents; handling, 16 cents; and setting derricks, etc., 32 cents; and, finally, for comparison, it is necessary to know that on this particular work which has been cited the foreman mason received 30 cents, the regular masons 25 cents, and the helpers 15 cents, per hour.

Considerable care is required to keep and compile such figures; but they are of the utmost importance. For example, the cost of cutting a given stone, together with its delivered price, determines whether or not it can be used in a certain work as against stone from a different locality.

Every contracting engineer keeps track of such detailed costs in his own lines.

The great increase in the earning power of railroad properties in this country is the subject of wide comment. On any given railroad this increase of earning power began with the carefully-planned improvements in grades, alignment and strength of roadway, properly executed by the engineer. It was further secured by having the improvements completed at the lowest ultimate cost; and, finally, by the engineer providing many facilities for keeping down all items of maintenance cost.

Referring now particularly to this last factor, we find that a spirit of rivalry exists in every good workman, and this may be brought into practical use, even if the employee be no higher than a track laborer. It is useless to depend wholly, for the best results, on driving such laborers and their foreman; and the same statement applies to every man worthy of employment on a railroad.

On some closely-operated railroads this plan is followed in much detail and with great success. For example, a simple statement is issued monthly by such a railroad, showing the actual cost of such hum-drum work as the putting of a tie in track on each roadmaster's division of the road. A rivalry is at once induced among all the foremen of every division to be the lowest. A similar statement giving the cost of placing lumber in bridges per thousand feet, B. M., in making repairs, brings about the same rivalry among carpenter forces; and all this produces an absolute and proper reduction in cost of maintenance.

The grand result sought is secured when the total cost of handling

Mr. Churchill. freight per ton per mile is less than during the corresponding month of a previous year.

Comparative monthly statements, in much detail, showing the cost of operation in the different departments of such a railroad, are responsible for many of the large savings secured by the encouragement of the spirit of rivalry among its employees.

It is the engineer on a successfully operated railroad to-day, in point of cost, who compiles much of the information as to costs necessary to secure this grand result in railroad operation.

Surely the engineer's strength and usefulness are largely in ascertaining and keeping unit costs on each class of work with which he is connected, or for which he is responsible.

Mr. Hatton. T. CHALKLEY HATTON, M. Am. Soc. C. E.—There would seem to be only one side to this question: How can any engineer give his client a reliable approximate estimate of the cost of a proposed piece of work, unless he has first taken very careful estimates of the cost of preceding and similar work? Mr. Churchill mentions the results of taking careful estimates of costs in relation to railroad maintenance and railroad construction, and the care with which such records have been made. The same results have been obtained by the speaker with relation to public work.

Some twelve or thirteen years ago he designed a system of sewers to cost about $1 750 000, and to be constructed from year to year as the funds might become available. When the work began, no reliable approximate costs of the work could be made, as it was to be done under all kinds of conditions; but, at much expense, a systematic record was kept of the actual cost of excavating each linear foot of trench under each condition, whether in rock or wet ground, and whether in paved and unpaved streets; the actual cost of brickwork per linear foot, for each size of sewer and each foot of pipe; and the cost of each manhole, inlet and every other appurtenance, until, at the end of three years, the speaker had compiled a record of actual costs which enabled him to determine, within 1 or 2%, the probable cost of the remainder of the work. These records were compiled in such a manner as to enable him to determine how many bricks could and should be laid by a bricklayer under the several conditions; how many feet of pipe of the various sizes should be laid per day, and the quantity of cement and hemp required to lay it; how much trench one man should excavate in a day, and how much per cubic yard it cost to remove rock.

At the end of three years it was found that the contractors were making too much profit, and the speaker recommended that the minor portion of the system be built by day's labor, and that the larger work, requiring special plant, should be done by contract. This work proved so successful that it was determined to do all work by

day's labor, with the result that the contractor's profit was saved in every instance. A contract would be let out to build in one street a sewer which was of the same nature as was being built upon another street by day's labor; and this proved the case clearly. Mr. Hatton.

The keeping of these accounts has had the following result: Each foreman, when his particular work is finished, knows just how much it has cost, and, if this cost exceeds the cost of similar work under another foreman, he knows at once that he is not up to the standard, and a continuance would mean the loss of his job; but, aside from this fear, this system makes each foreman an enthusiastic worker for a reputation, and results in a financial benefit to his employer. If the cost of each superintendent's work is not made known to him, what means has he of knowing whether his work is or is not successful? And unless the engineer keeps a careful record of the cost, he cannot give the foremen such information, and the burden finally falls upon him.

OBERLIN SMITH, M. Am. Soc. C. E.—It may be of interest to change the point of view to indoor work, and speak of manufacturing cost in factories; the speaker's experience having been more particularly in that line. There is a very common belief that manufacturers make enormous profits; that people who run machine-shops, and make goods that outdoor people have to handle afterward, are getting fortunes—not small fortunes, but big ones. It is a common idea, when people send to a machine-shop to have repairs done or machinery built, that if the charge is made by the hour, at say 50 cents or more, there is a profit of about 100 per cent. The ordinary public, and perhaps even some engineers who do not have to do the work, are apt to say: "Behold! Their men are paid 25 cents an hour and they charge you 50 cents, a very nice thing in profits." But they ignore the little items of fixed charges, about which much is not generally known by outsiders. These, however, as a matter of fact, sum up to a very large amount. If we consider a medium-sized machine-shop, employing say one hundred or two hundred men, where (there being a good many boys) the wages average, perhaps, only 20 cents an hour, the expense-rate, or hour's burden, that has to be put on each and every hour worked by producers, is usually about the same amount. That is to say, the sum paid for wages upon a job must have about 100% added, to cover ordinary running costs. One modern way, therefore, of finding costs in such establishments is to take the material for any given job, at its actual cost, delivered at the factory, including freight, waste, etc., plus the wages actually paid, plus the "burden" on each hour worked by those men in the factory who really produce something. There are, of course, a good many non-producers whose wages go to expense account. This burden is very often put at 20 cents an hour. It may run as low as 15 and as high as 25, but 20 seems to be Mr. Smith.

Mr. Smith. a somewhat safe average for the ordinary medium-sized machine-shop in the United States. A burden rate is ascertained by taking the total expense of running the business, outside of material bought and wages paid. This usually consists of: interest on capital, or, perhaps, rent; insurance; taxes; commercial expenses of selling (the most variable item in the whole account), including advertising, traveling, bad debts, part of office expenses and salaries of officers and clerks, together with many sundries; repairs to machinery and buildings (a very large item); fuel, oil, light and other consumables; wages of non-producers about a factory, as engine-men, janitors, etc., etc.

These items, added up at the end of the year, divided by the total number of hours' work made by the producing class, will give the hourly burden. Of course, it usually comes out in fractional figures, but an approximate rate, in round numbers, is good enough—if set high enough. The burden for each year is based upon the previous one, and hence cannot be really accurate. It will be seen, therefore, that a machine-shop man who uses medium-sized tools, may very likely find his work costing him 40 cents an hour, 20 cents for wages and 20 cents for expense. In some shops, however, the wages will average 25 or 30 cents, and so the cost may be 45 or 50 cents. Hence, with a not unusual charge of 50 cents an hour, there is a question whether there is a total net profit of as much as 10 per cent.

In using very large machine-tools the average price per hour is put higher because of the greater amount of room these machines take up, and their greater interest and repair account, to say nothing of their likelihood of standing idle more of their time. The machine-shop man, therefore, sometimes perpetrates a charge of $1.00 an hour, or more.

Hence the outside public who use machines should understand that the profits on making them are not abnormal. They are moderate, and it takes a good deal of time and care to find out what they are, and much good management to keep things going so that the profit comes out on the right side and does not prove to be a minus quantity.

Mr. Worthington. CHARLES WORTHINGTON, M. Am. Soc. C. E.—One of the most important acts an engineer has to perform is the preparation of accurate estimates of preliminary cost, in connection with any work he may be called upon to design. His clients, of course, want to know at the outset what the work is going to cost, and, possibly, how certain variations in design will affect the total cost. The engineer, therefore, should be prepared to make these estimates on short notice. To determine the cost it is necessary to have, first, an accurate estimate of the quantities of materials required in the work, which is a matter of calculation; and then accurate unit costs which will apply to the items making up that estimate. To determine these unit costs it is necessary to look to the past experience, either of the engineer himself

or of others. In some lines of work, as in bridge manufacturing, the unit costs have become quite generally known, but in many other lines they have not; and engineers who publish the unit costs of work actually constructed, with specific descriptions of the local conditions affecting the same, do a great service to the profession at large. Many of the statements of cost which appear in the engineering periodicals from time to time have little value, for the reason that the unit costs are not given, and local conditions are not clearly specified. Mr. Worthington.

FOSTER CROWELL, M. Am. Soc. C. E.—There is one consideration of this subject which is important: A great many engineers are deterred from an attempt to ascertain the unit prices of the work in their charge, because they think it is a very difficult operation to collect and arrange the data. That is true if the desire is to have an absolutely accurate account which will balance, but, for the purpose in view, it is not necessary that that degree of accuracy should be attained. If such accuracy were to be attempted it would necessitate a duplicate set of accounts, adding much to the cost, and occasioning very great difficulty in getting the accurate data; but it is quite possible to reach a sufficiently close approximation to the cost, and to the average price. Mr. Crowell.

Mr. Oberlin Smith has spoken of the figures of cost which he had obtained in a given case and was quite content to express it in terms of an easy average. He did not think it necessary to go down to a decimal of a cent or even to a cent. Now, if engineers in charge of work educate and instruct their staff to collect certain items of information as the work proceeds, it will be found quite easy at the end of the work to approximate the cost of any one of the items, or all the items, with sufficient closeness for comparison and for reference in undertaking other work of the same kind.

CHARLES G. DARRACH, M. Am. Soc. C. E.—The speaker would answer this question in the affirmative; and, if the affirmative answer to Topic No. 1 is accepted, there is no difficulty whatever in keeping the accounts. Mr. Darrach.

In further commenting upon these two subjects, it may be said that the more experience one has in carrying on work, as suggested, the more will it inure to the benefit of the owners and to the knowledge of the engineer.

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AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

RELATIVE PERMANENCE OF STEEL AND MASONRY CONSTRUCTION.

An Informal Discussion at the Annual Convention, May 21st, 1902.*

SUBJECT FOR DISCUSSION.

"Is steel susceptible of being made as permanent a building material as masonry?"

By Messrs. CHARLES G. DARRACH, EUGENE W. STERN, GEORGE F. SWAIN, CHARLES C. WENTWORTH, OBERLIN SMITH, WILLIAM R. WEBSTER, JAMES OWEN, E. T. D. MYERS, JR., W. HILDENBRAND, H. S. HAINES, A. L. JOHNSON and F. LYNWOOD GARRISON.

Mr. Darrach. CHARLES G. DARRACH, M. Am. Soc. C. E.—The speaker approaches this subject with some trepidation, as it is worthy of higher talent than he possesses.

To deal with the subject properly, there should be not only discussion, but contention and consultation, so that it may not be recorded among the dead by the epitaph which heads our publications: "This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications."

The speaker would suggest that the subject be amended so as to read, "Is Metallic Construction, or the Combination of Metal and

* The discussion of this subject, for which no formal paper was presented, is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion. (See Rules for Publication, *Proceedings*, Vol. xxv, p. 71.)

Communications on this subject received prior to September 26th, 1902, will be published subsequently.

Cement Concrete, Susceptible of Being Made as Permanent a Building Material as Masonry?" Mr. Darrach.

Many years ago, the late Julius W. Adams, then President of the Society, suggested to the speaker that it was pre-eminently the business of the engineer to adapt the *motif* of his construction to the genius of the locality in which his field of operations lay. This is, in fact, the chief business of the engineer, and is using the best and cheapest means for the end to be attained.

It must not be forgotten, however, in making comparisons, that the best materials may be manipulated so as to produce inferior results, and the proper use of materials in composite engineering construction is as absolutely necessary as in the domestic arts, which please our palates, for it is well known that the cook can either spoil the pie or make the pudding.

Before determining upon a method of construction, there should be considered, not only the first cost, but also the expense of maintenance. The ease of inspection during erection should also be considered, as well as the adaptability of the material to attain the most economical results.

A knowledge of the relative strength of the various materials, and also of the causes for deterioration and decay should be attained. With this knowledge the problems will reduce themselves to some degree of simplicity. This knowledge can then be supplemented by observation and experiment, so that there need be no reason to fear results. Knowing the disease, the remedy therefor can be obtained.

The idea that masonry is the *sine qua non* of all permanent construction seems to the speaker to be without foundation. Permanence of masonry construction depends, not only upon proper design, but also upon perfect workmanship. All who have had any experience in construction know well that the most trying and difficult task of the engineer is to have masonry properly erected. In masonry construction, dependence must be placed upon the physical value of the stone, sand and cement. The stone, being a natural product, may or may not have that degree of permanence expected by the engineer, and, to meet this contingency, a large factor of safety is generally introduced in the calculations for masonry construction. Also, in many cases, where masonry is used, it is impossible to design the structure so that the economical quantities of material to meet necessary requirements can be used.

As has been intimated, masonry, as well as metallic construction, may be subject to deterioration and decay.

In using metallic construction, it is possible to calculate the stress upon the structure with a far greater degree of accuracy than can be applied to a masonry structure; consequently, the factor of ignorance can be reduced and the quantity of material used be

Mr. Darrach. nearer to that which is theoretically required. Inspection during construction and erection, and after completion, is more convenient, and, knowing the causes for deterioration, the necessary remedies and protection may be readily applied.

The use of concrete, or artificial stone, appeals to the speaker with much force. By its use artificial stone of equal value throughout the entire content can be obtained, and that value can be determined in direct accordance with the material of which it is made; so that the composition of the artificial stone can be adapted directly to the use for which it is intended. The cost of construction for equal values in artificial stone is generally much less than if natural stone were used.

Artificial stone, or concrete, forms a protection against the usual deterioration of metallic construction by atmospheric influence.

The logical conclusion seems to be that the best method of construction would be composite, using artificial stone and metal. Artificial stone, or concrete, not only forms a protection for the metal, but adds its value in resisting stress, and, except in subterranean and subaqueous structures the deterioration of metal encased in cement concrete of proper composition may be disregarded.

There are many examples of structural metallic work encased in concrete where no deterioration is shown, even from ancient times. The modern system of iron construction encased in concrete or brick masonry, used in high office buildings, shows that, when properly constructed, there is no observable deterioration in the metallic work. The Drexel Building, Fifth and Chestnut Streets, Philadelphia, was constructed in the years 1886–87. The speaker has removed portions of the ironwork in that building, and could see no deterioration whatever.

In the year 1891, the speaker made a cement floor and walk over a pipe tunnel, the upper surface of which was exposed to all atmospheric influences. This floor was of cement concrete, about 4 ins. in thickness, and had a span of about 5 ft. It was reinforced by bands of ordinary chicken-wire fencing, 16 ins. in width, laid across the tunnel and spaced 16 ins. apart. A bed of mortar, composed of cement and sand, about 1 in. thick, was laid upon a horizontal plank center, and brought up flush with the top of the side-walls of the tunnel. Over this mortar the chicken-wire was laid, extending over the side-walls. The cement concrete floor, 3 ins. in depth, was laid upon this chicken-wire, and finished, the walk being about 7 ft. wide. Although this walk has been in use for eleven years, no deterioration is apparent, nor has there ever been any leakage, even during the most severe storms.

In relation to this, attention is called to what the speaker considers faulty construction. The concrete floors of most office build-

ings are of cement, ashes or cinders. The resultant concrete is not impervious. The large quantity of water used in construction is retained within the exterior skins of these floors for a long period, and, no doubt, is a detriment to the metallic construction of the floors. Mr. Darrach.

In the year 1884, the speaker constructed a water-works well at Redbank, N. J. This well was some 15 ft. in interior diameter, and was sunk from the surface of the ground to a depth of about 60 ft. The lower half, or 30 ft., was below the ocean level, and the entire well, to within 5 ft. of the surface of the ground, was under the ground-water level. The water arose in the well to within 8 ft. of the surface of the ground, so that the well casing, 20 ins. in thickness, constructed of hard brick laid in Portland cement mortar, was continually in contact with water on both sides, and at times, even during construction, was under a pressure from the outside of more than 40 ft.

For reinforcing the brick shell during sinking, ¾-in. iron rods were extended from the cutting curb upward through the masonry; and, at intervals of about 6 ft., large wrought-iron washers were placed over the rods and extended around the entire circumference of the well casing. This construction was adopted to reinforce the green masonry of the casing during the operation of sinking. It would be interesting to examine this ironwork for the purposes of discussing this subject.

In the speaker's opinion, the hue and cry raised in relation to a properly constructed iron skeleton, in modern high buildings, is without foundation.

In buildings where the ironwork is concealed within fire-proofing or concrete, there is little reason to suppose that any deterioration takes place, and the speaker will venture to state that, if the temperature and the humidity of the atmosphere immediately adjacent to the metallic structural work were observed and recorded, there would be found but little, if any, difference throughout the year.

Greater care, and concrete richer in cement, should be used for subterranean and subaqueous composite construction, and, in some cases, it would be advisable to use an asphaltic concrete, so as to absolutely prevent the possibility of any moisture coming in contact with the metal.

The numerous cases of electrolysis in subterranean metallic pipes suggest a criticism which has not as yet been presented to the speaker. Is it not possible that, in subterranean and subaqueous work, metal, even when constructed in cement concrete, may be subject to electrolysis similar to that experienced in metallic water and gas pipes? The speaker is of the opinion that all such subaqueous and subterranean constructions should be laid, as heretofore indicated, in an asphaltic concrete, and efforts should be made to force our legislators to pass

Mr. Darrach. laws preventing the use of the ground for an omnibus commercial electrical conductor.

We can also substitute for cast and wrought-iron pipes a cheaper and more permanent conduit, constructed under the composite system. The capacity of metallic water pipes is materially diminished by the formation of nodules on their interior surfaces, and, with some waters, the life of iron pipes is merely a question of a very few years.

Composite pipes, constructed of concrete reinforced by metal, can be constructed so as to have the necessary strength without the loss of conductivity due to the metal nodules, and it is not necessary that the concrete of which they are composed should be of such richness as to absolutely prevent at first the transmission of moisture, except when the liquid conducted is free from suspended matter. Conduits carrying either turbid water or sewage soon fill up the pores in the concrete, and make it impervious.

In 1894, the speaker constructed a septic tank for the Insane Asylum at Wernersville, Pa. The diameter of the tank was 25 ft., and the depth of water was 14 ft. The well was constructed of hard brick, laid in Portland cement mortar, and had a maximum thickness of 21 ins. There was an inside coating of plaster, ½ in. thick, made of equal parts of Portland cement and sharp sand. Tests were made, through a period of ten weeks, at the end of which time the masonry was practically impervious.

There is a paucity of experimental knowledge as to the strength of composite construction; the field is wide, of great importance, and deserves the attention and study of the members of our profession.

Before closing, the speaker would suggest that further experiment be instituted as to the possibility of making a metallic weld, to avoid as much as possible the use of bolts and rivets. He is aware that the electric weld does not give a resultant value of 100%, but he is of the opinion that the Society would be gratified with a knowledge of the best results so far obtained.

Mr. Stern. EUGENE W. STERN, M. Am. Soc. C. E.—Discussing this question from the standpoint of the protection of iron and steel construction in buildings, the experience of the speaker is that iron does rust in buildings. That is, it rusts unless properly protected. Therefore, it is a very important question to determine what kind of protection it needs to prevent this, under different conditions of exposure.

In the interior of buildings, where there is no chance of moisture or acids attacking the iron, and where it is usually surrounded by fireproofing materials, the danger from rust is very slight. The usual coat of paint appears to give all the protection necessary.

The speaker has seen ironwork taken from the interior of buildings, in one case after thirty years, in which the shop marks of white paint and the brown coat of red oxide paint were in as perfect condition as if done but recently.

Mr Stern.

In the exterior walls of a building, however, and in the roof and cellar construction, it is an entirely different matter. A driving rain will go through the outer coating of brickwork; roofs will somehow or other leak, and cellars rarely are absolutely dry. The speaker has invariably seen evidences of rust on the ironwork taken from the above-mentioned positions in comparatively recent buildings. The paint seemed to have disappeared entirely in many cases where exterior brickwork was laid up against the iron. Where the mortar was in immediate contact with the iron, there was no rust; where the brick was directly in contact, there was considerable rust.

In a building in New York City, built in 1869, and now being taken down, cast-iron girders supporting the brick arches of the sidewalk construction were rusted about ⅛ in. where the brick was immediately in contact with the iron, but where the mortar was directly in contact the iron was perfectly clean and black, looking as if taken from the sand only yesterday. The evidence that paint protects ironwork thus exposed, for any length of time, is not forthcoming. The paint seems to disappear entirely in a few years. Nor, in the speaker's opinion, does it help matters to prepare the surface of the ironwork, prior to painting, in the most painstaking and thorough manner, even using the sand-blast to remove the mill scale. Some of the paint is rubbed off the ironwork during erection, notwithstanding that the very greatest care is used. It is an inseparable condition, from the nature of the work, that this happens. There is then a starting point for rust, and this will follow more quickly on a sand-blasted surface than on one having its mill scale.

The speaker is strongly opposed to the use of the sand-blast on ironwork for buildings. It does not help to protect iron permanently, and the expense, therefore, is not justified. For this reason the following method of protection is recommended: All the columns and girders in the exterior walls, the roof, the cellar, and wherever exposed to moisture or acids, should be surrounded with Portland cement mortar, and the bore of the columns in such locations should also be filled solid with this mortar.

Broken stone in the mixture is not recommended, because the voids may not always be filled; and cinders are strongly objected to, because there is good evidence to show their very harmful effect.

A building having its frame thus protected should remain structurally sound, judging from evidence, for many years, perhaps longer than one made entirely of masonry, unless of the best quality.

Mr. Swain.

George F. Swain, M. Am. Soc. C. E.—People in general have come to consider iron or steel as rather perishable materials when compared with stone. Many persons form this idea by considering the old stone structures of the Greeks and Romans, notwithstanding the fact, referred to by one speaker, that there are a great many stone

Mr. Swain. structures which have proved very perishable. Many instances can be cited of bridge abutments built of sandstone or limestone which have practically gone to pieces within thirty or forty years. In judging of the ancient stone structures of Greece or Rome, we must also remember the difference in climate between those countries and Northern New England. It may not be out of place to point out also some differences between the ways in which steel and stone structures act. A stone structure is a comparatively simple one; it acts by its own weight; it acts generally in simple compression; its durability is a question of stability rather than of strength, and the loads may generally be increased greatly without endangering it.

A steel structure is very different. It is a complex structure, involving complicated stresses and strains; its strength is a controlling factor in its durability, and any increase of load reduces correspondingly its margin of safety. Engineers who have had much to do with questions of renewing bridges will agree with the speaker that cases in which bridges have had to be renewed on account of the actual wearing out of the material are comparatively rare. Of course, there are cases where corrosion is active, especially in bridges over railroads, but, leaving out such cases, the greater number of renewals which have taken place are due to other causes. One of these is defective design. Engineers are learning more and more every day in regard to the details of steel structures, and they are experimenting and studying the various connections and details. The result is that we find that structures built twenty or thirty years ago, and supposed to have an ample factor of safety, really had a much smaller factor. Moreover, as everyone knows, the loads to which steel structures are exposed have increased enormously. These are the two elements which have caused the principal renewals of bridge structures. These elements will continue to be present, and, as long as they are present, we cannot hope to have steel structures in general as durable as the best stone structures would be. In the case of a steel-frame building, the loads, presumably, are not to change very much, and with good design the actual durability of the material should govern the life of the structure. As to what that durability will be seems very uncertain. All the engineer can do is to take every precaution he can to insure the permanency of his steel. The speaker agrees with Mr. Stern that the steel should be completely enclosed in concrete, but, even under these conditions, he does not think the steel will last as long as the best masonry.

Mr. Wentworth. CHARLES C. WENTWORTH, M. Am. Soc. C. E.—The answer so far given to this question is that steel, when embedded in concrete to a sufficient depth, is permanent. A structure in which the steel is thus hidden becomes at times as essentially one built of concrete as of steel, and may be even more so. The fact that, in most cases, it is

impracticable to adopt a composite construction, rather than one all steel or all concrete, renders it still necessary to seek a more complete answer to the question; especially if it be considered, as it must be, that bridges are made of "building material." Mr. Wentworth.

The answer given, for instance, is inapplicable to the East River bridges, built or building in New York City, and to the greater part, by weight, of ordinary railway bridges. It is surely inapplicable to more structural steel work, by weight, than it is applicable to all kinds.

The protection afforded by concrete is afforded by paint, but in a less degree. The objection to paint as an answer to the question lies in the fact that much structural work is inaccessible after erection, and that, in all likelihood, paint will not be applied properly or with sufficient frequency even where the work can be reached by the painter.

A more complete answer to the question appears to lie in the electroplating of structural steel with copper or aluminum. This has already been done, to a small extent; but the subject does not appear to have received the attention it deserves.

The speaker sees no reason why such plating need be of excessive cost. Aluminum is an exceedingly abundant element, and is becoming cheaper; copper may retain its value. Metallic aluminum may not be needed in the process, but such aluminum salt as will serve when in solution as the source of the metallic aluminum finally composing the plating.

Of course it would be impracticable to plate steel as it comes from the rolls, as rivet heads and sheared edges would need subsequent plating; but each structural piece, ready for shipment and erection in the structure, could be plated, and the details of field connections arranged with a view to their permanency on the same lines.

The speaker does not wish to appear as objecting to the use of concrete structures stiffened by steel, with the incidental protection afforded to the steel by the concrete. Such structures are entirely proper and appropriate in very many cases; but, in conclusion, he wishes to say that the plating of structural steel, as a more general answer to the question, is well worthy of the attention of the members of this Society.

OBERLIN SMITH, M. Am. Soc. C. E.—The speaker is not experienced in putting up big steel buildings, but it seems to him that a certain precaution should be taken, which, perhaps, usually is not, and which will be mentioned later. Some of these buildings have been up a good many years and seem to be very strong, but after this generation is gone—fifty or one hundred years hence—if there is no way to examine all that hidden metal inside the masonry, how are people Mr. Smith.

Mr. Smith. going to feel about the stability of such buildings? When will the time arrive for them to come down of themselves? There should be, therefore, some systematic method of examination.

Of course, after many years, the owners may tear out some of the masonry and examine the steel, but it would be a small matter now to provide inspection holes, properly covered, and to differentiate and classify the various conditions of possible deterioration to which the metal may be subjected.

Certain parts of the building which are most likely to rust, and where such rusting is most likely to cause accidents and damage, would be in one class, while other parts which are not so likely to be affected would be in another, and so forth. In every building, in several proper locations, let there be certain places left where the metal can very easily be exposed, and again covered up—of course in a fire-proof manner. This would be done instead of merely tearing away a building at random, with perhaps considerable damage and with consequent expensive repairs.

To find out how the steel is really getting along, there should be certain times for observation, with definite intervals between. These intervals might be five, or ten, or twenty-five, years—as experience should indicate. The most risky "classes" should be examined the oftenest. In general, there should be certain definite methods of inspection, and definite places for inspection, and definite times for inspection of this buried and perhaps much-suffering metal, not only that such may be done with less damage to the building, but that it may be done thinkingly and systematically—instead of waiting for some Chicago post office to become obsolete that we may see whether it continued safe until the end. If not done in such a manner all may be neglected, and intervals which are uncertain may become of infinite length.

Mr. Webster. WILLIAM R. WEBSTER, M. Am. Soc. C. E.—The examination of many old bridges and other structures has shown that the white-lead marking letters of the mill are intact, and that the metal is better protected at these places than at others. That is, the plates and shapes are generally marked while hot, and before the material has had a chance to rust; but the full importance of applying the protective coating while the metal is hot has not been appreciated.

The ordinary oiling at the mills has not been satisfactory, as the material is generally made sticky and difficult to handle in the shops. In relation to this, attention is called to a railroad spike dipped in oil, while slightly heated (in accordance with the specifications for an export order). Under this treatment the oil quickly dried and formed a good, hard protective coating. This process might be applied to ordinary structural shapes and plates with great advantage; the material being cleaned with brushes and an air blast, and the oil applied

while the material is still hot, the coating in no case being heavy enough to interfere with a thorough inspection for surface defects. The shop painting, of course, should be applied in the usual manner. Mr. Webster.

Electric welds have been referred to as being practicable for welding beams to beams, or beams to columns, in buildings. This would be a step in the wrong direction, as reliable welds of this character cannot be made. The size of the grain is raised during the heating, and there is no chance of putting the required work on it to break up the grain and produce the fine silky structure. That is, electric welds would be fatal to any work that is subject to shock.

JAMES OWEN, M. Am. Soc. C. E.—It might be interesting to know that, in endeavoring to find some records of the strength of concrete beams, the speaker found, in the library of the Society, the report of some experiments made by Mr. Kirkaldy in 1854. Mr. Kirkaldy at that time had made an elaborate investigation of the strength of the admixture of concrete with iron rods and iron wire. Results showed at that time that the strength of the combination of the two materials, iron and concrete, was increased by more than two and one-half times that of the simple concrete itself. This is quite in accord with the present experiments in that line, and it is interesting to note that while these investigations were made so many years ago, it is only of late that the profession has appreciated their importance. Mr. Owen.

The speaker had a peculiar experience in relation to the strength of an ordinary bridge built with iron beams and brick arches and covered with concrete. The span was 15 ft. The bridge had been built some eight or ten years when the local engineer decided to change the grade of the street, and raised it about 6 ft. This alteration imposed on the bridge itself an extra load of 900 lbs. per square foot. That, with a previous allowance of 200 lbs., made a total of 1 100 lbs. The bridge was originally designed for a live and dead load of 300 lbs. and a factor of safety of four. A critical examination of the bridge, after the extra load had been on about six months, showed no rupture of any kind and no apparent deflection. The bridge is still in use.

It may be presumed, therefore, that the combined use of steel and concrete is susceptible of a great deal of further development, and that its ultimate strength is apparently unknown.

E. T. D. MYERS, Jr., M. Am. Soc. C. E.—During the summer of 1901, a rifle barrel was pumped up through the 20-in. pipe connected with the centrifugal pump which was used in dredging out the historic dock immediately in front of Libby Prison. It arrived at the usual joint, just in front of the pump, which was intended to stop obstructions too large to pass through the pump. The pump was stopped and the rifle barrel taken out. It was found that the blue enamel on the barrel was intact on at least 90% of its surface, and the sight could be raised and lowered without the slightest difficulty. The date Mr. Myers.

Mr. Myers. on the barrel was 1856. It was probably thrown in the water in 1865.

The water there is fresh, and is entirely free from lime. It is what is known as a "kind" water for boilers. The speaker does not know whether metal would last that way in other waters, but he has pumped up and dug up shells and rifles which were not rusted.

The depth of water in the dock was originally 16 ft., and the depth of the silt was about 4 ft. The pump was working at a depth of 22 ft. It is impossible to state the depth at which the rifle lay, but it probably came from the 16-ft. level. The bottom is composed of sand and gravel, and the silt lying upon it came from the James River, which runs through a red-clay country. The rifle barrel, therefore, had about 16 ft. of mud and fresh water above it.

The speaker does not feel competent to discuss this topic, but he is deeply interested in it, and hopes that the result of the discussion will be the addition of much valuable information.

Mr. Hildenbrand. W. HILDENBRAND, M. Am. Soc. C. E.—With reference to the old Roman viaducts and aqueducts mentioned in this discussion, which are frequently quoted as evidence of the longevity of stonework and its superiority over iron structures, the speaker wishes to draw attention to the fact that in other Roman structures may be found equal evidence of the durability of iron. Remnants of bridges over the Rhine, built by Julius Cæsar, have been dug up during the past fifty years, while the work of regulating the bed and current of the Rhine has been going on. In Cæsar's "Commentarii de Bello Gallico" one of these bridges is minutely described, corresponding in construction to what would now be called a timber trestle, consisting of heavy oak logs connected with iron bolts, clamps and spikes. Quite a number of these logs were found under the bed of the river, nearly 2 000 years after they had served for carrying the Roman legions over the Rhine in their attempt to subjugate a free nation, and the timbers, as well as all iron bolts and spikes, were in a perfect state of preservation.

This fact corroborates Mr. O'Rourke's assertion that iron submerged in pure water will probably never corrode.

Of course, every object in this world perishes, or, rather, disintegrates and changes into some other form; but, if building materials can be preserved for several thousand years, it may be said that, for all practical purposes, they last forever.

The question whether metal will in the future be considered as permanent and durable a building material as stone cannot be solved at the present time, and it is not likely that any who are here will live to see it solved. The answer to the question cannot be found by theorizing, but depends entirely on experience, which should extend over centuries.

At present we have, so to say, no experience at all about the dura-

bility of iron or steel structures. It is barely sixty years ago that the first iron bridges were built, and it is doubtful whether a single one of that age is in existence to-day. Nearly all the early iron bridges have been removed and replaced by modern structures, not on account of having been decayed or weakened, but because they had outlived their usefulness, and stronger ones were required to accommodate the increased and heavier travel of modern times. Our experience as to the durability of iron and steel structures, therefore, is very limited, and only of recent date. Mr. Hildenbrand.

If a stone building and a steel building were erected side by side, and both structures were left to themselves, without any attempt to protect them against the effects of the atmosphere, there is no doubt that the stone building would stand very much longer than the steel building. In New York City there is an example in the New York and Brooklyn Bridge. The massive stone towers, which are now more than twenty-five years old, have no protection against the weather and have never been repaired. They are to-day as they were left by the hand of the mason twenty-five years ago, and, according to a recent thorough inspection, they are just as good and perfect as they were on the day they were finished. On the other hand, the steel and wire-work requires constant attention; there is hardly a time when no men are seen suspended in the meshes of the wire-work repairing something or putting on a coat of protective paint.

The speaker has had the opportunity of examining suspension bridges erected more than forty years ago, and while he found the cables, as a whole, in perfect condition, he also discovered one or two places where, through the accumulation of water or through imperfections in the protective paint, the wires were considerably corroded and needed repairs. All of this shows that metal structures require attentive watching and constant renewal of paint or other protective coverings, and that any oversight or inattention is followed by grave consequences.

With our present knowledge, therefore, we may sum up by saying that unprotected masonry, as well as unprotected ironwork, is perishable, but that the former will last much longer than the latter. However, if iron or steel be well protected, it is known that it will not decay in thousands of years, and will be as durable, if not more durable, than any stonework. Will the means for an efficient and permanent protection of steel ever be discovered, or will a new metal be found which has the same strength as steel and which naturally is not subject to oxidation?

H. S. Haines, M. Am. Soc. C. E.—Mr. Hildenbrand has referred to iron bolts in bridges built by Cæsar across the Rhine. In the Colosseum, built about A. D. 80, the courses of heavy travertine masonry, laid with knife-edge joints, without mortar, were connected by iron Mr. Haines.

Mr. Haines. cramps fairly well protected from the weather. Many of these were cut out in the Middle Ages, but those which remain appear to be in good condition. The vault of the Pantheon, 140 ft. in diameter, is of concrete supposed to be strengthened with iron rods. This vault, built about A. D. 125, is, to all appearances, in excellent condition. From these instances, it would seem that iron, used structurally in connection with stone or concrete masonry, may remain efficient for nearly two thousand years.

Iron is not readily oxidizable in pure water, for the oxygen therein chemically combined is only separable at an excessively high temperature. It is the atmospheric oxygen ordinarily present in water that is the oxidizing agent. Water absorbs carbonic acid gas to an extent equal to its volume, and the water thus acidulated acts powerfully upon iron or steel. It follows that in large cities where the atmosphere is heavily charged with the products of combustion, the falling rain would be correspondingly charged with carbonic acid gas, and, therefore, that the effect of oxidization upon steel construction should be proportionately greater from exposure under such conditions.

Mr. Johnson. A. L. Johnson, M. Am. Soc. C. E.—In reference to a statement concerning the corrosion of the steelwork in the large buildings in Chicago, C. T. Purdy, M. Am. Soc. C. E., was one of the members of a Commission to examine and report on the condition of those buildings. The speaker having talked with Mr. Purdy recently concerning this matter, it may be appropriate to give some of the results as described by Mr. Purdy. His report has undoubtedly been printed ere this, and probably, therefore, there will be no objection to the promulgation of the information at this time. The Commission examined quite a number of the buildings in Chicago and found numerous cases of corrosion in the columns; but it was not developed that the corrosion was confined to the outside columns, or even that it was greater in them than in the interior columns. The beams in the foundations, Mr. Purdy said, were found to be in uniformly good condition. The Commission's recommendation would be that in future all the steelwork for these buildings should be entirely surrounded by a Portland cement or lime mortar, this covering being filled in solid behind the fire-proofing.

In St. Louis a very well-constructed building, erected about twenty years ago, is now being dismantled. The construction consisted of solid external walls, cast-iron columns throughout the interior, and steel beams painted with red oxide of lead paint. The building was eight stories high, and of fire-proof construction, the floor arches being mainly of brick, though there were also some concrete arches. The steel throughout is in a thoroughly well-preserved condition, it having been in all cases entirely embedded in Portland cement mortar or concrete covering. The paint also has been thoroughly preserved,

and in the speaker's estimation an embedment in Portland cement mortar is the only means of preserving that preservative. Mr. Johnson.

Professor Spencer Newberry, Manager of the Sandusky Portland Cement Company, recently gave a lecture* in Chicago, which the speaker regards as one of the most valuable articles, with regard to steel-concrete construction, that has appeared in print for some time, covering, as it does, all sides of the question, and some sides in an entirely new manner; such, for example, as the theoretical considerations involved in the preservation of iron by Portland cement covering. In this article he shows that the cement, theoretically, is not simply a neutral or non-injurious agent, but is actively engaged in preventing the formation of rust.

The speaker's company has samples of steel embedded in cinder concrete, in the form of broken pieces of a test span, made in the fall of 1898, and tested in February, 1899, these pieces having lain on the ground uncovered, subject to the action of the elements, for more than three years. On numerous occasions these pieces have been broken open for the purpose of observing the condition of the metal, the most recent case having been before the Engineers' Club of St. Louis, last January, in connection with a talk given by the speaker; and in all cases, without any exception, the metal has been found to be as bright and clean as the day it came from the rolling mill. The quality of the cinders in this sample was considered very poor, containing a good deal of dirt, and the fine material was screened out. This the speaker regards as desirable, though not absolutely necessary, where cinder concrete is used, inasmuch as, if it is not done, a slight film of rust will be formed on the metal. This film, however, never increases in thickness, but, as it costs little to avoid it, the best practice would call for the screening of the cinders. In the speaker's opinion, the reason for this difference in action is due to the fact that the fine stuff contains finely divided particles of sulphur, which are readily dissolved by water, slightly acidulating the same, and, until the concrete dries out thoroughly, a slight corrosive action is taking place. This is soon neutralized by the influence of the Portland cement, but not before a film of rust, not in itself materially injurious, is formed.

Mr. Darrach has expressed himself as of the opinion that at the present time we are not able to calculate the strength of steel-concrete beams with any degree of accuracy. The speaker, of course, will have to take exception to that statement, he having on numerous occasions endeavored to show how this could be done, and, being of the opinion that the data with regard to the materials used being known, he could arrive at the maximum carrying capacity within about

*Before the Annual Meeting of the Associated Expanded Metal Companies, and reprinted recently in *Engineering News*.

Mr. Johnson. 15%, which is certainly close enough for all practical purposes, in view of the factor of safety used. Of course, the strength and the modulus of elasticity of the concrete and steel must be known, and, as to the former material, these functions are seldom accurately known, chiefly because no special tests are made to determine this for the materials available for that particular work. Their influence on the character of the design is enormous, and, on work of any considerable size or importance, these values should be obtained before the designs are prepared.

As to the relative lasting qualities of the different kinds of engineering structures, the speaker is of the opinion that only a few forms of stone masonry can compare in length of life with a concrete construction reinforced with steel properly distributed through the cross-section. Strange as it may seem to those not conversant with the facts, the maintenance charges for stone masonry, on many railroads, exceed these charges for steel structures in proportion to the relative quantities of each. On railway work it is usually a condition of taking what you can get, rather than what you would like to have. Many forms of sandstone are worthless. Limestone is dissolved in the course of time by atmospheric influences, and there are really only a few kinds of stone that can be considered as everlasting, and these are usually so expensive as to prohibit their use. A very good example of the dissolution of limestone masonry is afforded at the Cabin John Bridge. Underneath the arch may be noticed stalactites forming along the line of the mortar joints between the granite arch stones, from the spring line some distance up toward the crown. The back-filling of the arch consists of a considerable depth of limestone rubble masonry. A considerable quantity of water finds its way down through the haunches of the arch and then through the mortar joints of the arch ring, and the stalactites indicate that the air and water are dissolving this limestone backing. This same action exists, to a greater or less degree, in all limestone structures.

In a large city in Indiana the speaker recently examined some limestone bridge masonry which had been in place for about forty years, and much of it could now be scraped up with a fire shovel.

In the speaker's opinion, plain concrete construction would not be everlasting, on account of the cracks which are almost certain to develop in such structures, these cracks filling with water and freezing in the winter, and gradually getting worse and spawling off as the years go by.

In steel-concrete construction, if the metal is properly distributed and proportioned to the cross-section, these cracks can be absolutely prevented. The speaker's company has built walls 300 ft. long, with steel reinforcement, in which no expansion joints were provided, and in which not a sign of a crack is to be seen;

Mr. Johnson.

and would take a contract to build such a wall a mile long, under this guarantee.

To accomplish this result, however, it is necessary to have a subdivision of the metal reinforcement into small areas thoroughly disseminated through the section, just as in successful arch construction it is necessary to have the metal thoroughly disseminated in small areas through the upper and lower portions of the sections. Heavy concentrations of metal at points 2 or 3 ft. apart will not give the peculiar stretching quality to the concrete obtained by the other method, and which is essential to success.

When properly built, this steel-concrete construction will not crack; will not be disintegrated by frost; will not be dissolved by the elements; and, in the speaker's opinion, is the only kind of engineering structure that can be considered permanent, with the exception of one or two kinds of rock masonry, the cost of which in most cases would be prohibitive.

Mr. Garrison.

F. Lynwood Garrison, Assoc. M. Am. Soc. C. E.—Since there seems to be some confusion or misunderstanding regarding the corrosive action of atmospheric and other influences upon iron, it might be advisable, in this discussion, to state briefly a few of the most important characteristics of metallic iron that are pertinent to the subject, although, in so doing, the risk of repeating some well-known facts must be incurred.

(1) To begin with, iron is one of the metals most easily oxidized and affected by moisture, consequently it never occurs in the metallic state.*

(2) Iron does not undergo any alteration in pure dry air at ordinary temperatures.

(3) In moist air iron becomes coated with ferric oxyhydrate having approximately the composition $Fe_4O_3(OH_6)$. The rust varies in composition with the conditions under which corrosion takes place.

(4) According to Percy, iron does not rust unless there is an actual deposition of liquid water upon the surface of the metal.†

(5) The presence of certain gases and vapors, even in minute proportions, such as sulphuretted hydrogen (H_2S), hydrogen, chlorine, and acetic acid, accelerates rusting in moist air, though no liquid water may come in contact with the metallic surface. Carbon dioxide (CO_2) and ammonia gas are said to act less energetically in this respect.‡

(6) Iron rust often contains minute quantities of ammonia, due, it is supposed, to the decomposition of the water by the action of the oxide on the metallic iron, the oxygen combining with the iron, and

* Exceptions must be made where the iron is of undoubted meteoric or non-terrestrial origin. In such instances, it is usually alloyed with a large proportion of nickel.

† "Metallurgy of Iron and Steel," p. 27.

‡ Bonsdorff, "Répertoire de Chimie," Vol. 4, p. 171.

Mr. Garrison. part of the hydrogen uniting in the nascent state with the nitrogen of the air.

(7) Pure water deprived of air appears to be absolutely inert, as far as corrosive action is concerned, on contact with iron, even at 100° Cent.*

(8) Rust formed far beneath the water consists of black hydrated magnetic oxide.

(9) The formation of rust takes place in the beginning but slowly; after a thin coating has once been formed, the corrosive process goes on more rapidly.

(10) Aqueous solutions of potash, soda and ammonia, preserve iron from rusting, provided they are not too dilute.

(11) Water containing not more than one-fifth its volume of lime water is said to preserve iron from rusting.†

(12) The contact of iron with more electro-positive substances, such as zinc, retards corrosion; whereas contact with more electro-negative substances, such as tin, lead and copper, accelerates the rusting.

(13) Magnetic and similar oxides of iron, which constitute the basis of iron scale, protect the iron which they coat, but hasten the corrosion of rusted iron, whether such be the adjacent portions of the same piece or in separate pieces which are galvanically connected. This protective action is shown by the comparatively slow rusting of Russian sheet-iron, of "blued" iron, and of castings that retain their original skin.

(14) While contact with zinc and highly zinciferous brasses retards rusting, contact with copper, or brasses rich with copper, hastens it.

(15) According to Martell, the purer qualities of mild steel when used in ship hulls are more likely to be corroded than impure iron. A steel ship requires more care than an iron one. Nickel steel is not so likely to be corroded in salt water as the ordinary and purer grades of steel.‡

This array of more or less well-known facts might be indefinitely elaborated; however, it covers the subject completely in a general way. It seems to be a perfectly sound conclusion that, other things being equal, where likelihood of corrosion is effectually prevented, iron (steel) makes as permanent and durable a building material as masonry. Better, in fact, for, whereas the latter will certainly, in time, disintegrate, the former cannot. Unusual conditions may certainly exist in which the molecular structure of the metal may change; such, however, must be regarded as abnormal and exceptional.

A statement has been previously made in this discussion, to the effect that, inasmuch as iron properly covered with fire-proof material

* Mallet, Rept. British Assoc., 1840, p. 229.

† Gmelin Handbuch, Vol. 5, p. 185.

‡ Journal, Iron and Steel Inst., No. I, 1889, p. 66.

or concrete will not corrode, uncovered iron in the interior of buildings will be immune from corrosion because it is then covered from the weather on all sides. Were walls and roofs absolutely water or moisture proof, in fact, if the buildings were hermetically sealed, top, sides and base, then, and then only, would the interior metal be free from corrosive influences. As a matter of fact, in most cases, the dangers from corrosive deterioration are much exaggerated; the greatest objection to steel buildings is their instability in fires. Mild steel, at a white heat, is about as stiff as cheese, whereas masonry is not affected in the same way at high temperature, and resists collapse to a far greater degree. Mr. Garrison.

The speaker's belief is, that, in practice, a thick covering of cement concrete is the only material that absolutely protects iron from corrosion. Such a compound structure unites the advantages of both component materials, and greatly surpasses in strength and durability an edifice made of either alone.

All are familiar with the remarkable strength and endurance of "wire-glass," the glass sheet being cast and rolled so that the wire net is completely covered with the glass, imparting to the natural fragility of the latter a certain amount of elasticity and abnormal strength; the glass, in turn, absolutely protecting the wire from corrosion. So long as the wire is covered, such a composite sheet will hold together, unless broken by a force greater than the tensile strength of the wire.

Not being a structural engineer, the speaker may be unfamiliar with certain objections to composite concrete and metal structures; in his ignorance, however, he cannot but think that such compound constructions will be the true and logical line of development in the future.

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AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

THE CONTROL OF NON-NAVIGABLE STREAMS BY THE NATIONAL GOVERNMENT.

An Informal Discussion at the Annual Convention, May 22d, 1902.*

SUBJECT FOR DISCUSSION.

"In view of the numerous disasters caused by the contracting of channels, or the damming of small streams, should non-navigable streams be under the control of the National Government?"

By Messrs. RUDOLPH HERING, CHARLES G. DARRACH and FRANCIS COLLINGWOOD.

Mr. Hering. RUDOLPH HERING, M. Am. Soc. C. E.—This topic does not allude to the questions of diverting water from a water-shed, of silting up or of polluting streams; yet these are quite as important, and are pressing for solution. As they are also intimately connected with the damming and regulation of streams, it seems but natural that they should be considered in connection therewith, and the speaker accordingly takes the liberty to do so.

As civilization spreads over a country, changes take place in the physical character of the land surface by the decrease of forest areas and the corresponding increase of cultivated areas, allowing the soil to

* The discussion of this subject, for which no formal paper was presented, is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion (see Rules for Publication, *Proceedings*, Vol. xxv, p. 71).

Communications on this subject received prior to September 26th, 1902, will be published subsequently.

be more readily washed into watercourses, and, in populated centers, by the addition of surfaces more or less impervious to water. Changes take place also in the character of the water as it flows in the streams, and in the size and shape of the beds themselves. Mr. Hering.

The water when flowing is likely to change, both in quality and in the distribution of quantity. The more soils are exposed to washing by rain-water, the more soil particles will be brought into it, and carried in suspension by it, causing it to become more or less turbid. The sites of habitations and manufactories in city or country, and the application of manure to cultivate fields, cause every rain storm to bring into the streams organic matter which causes them to become more or less polluted, if not directly offensive, and injures the water, either for domestic consumption, for fish life or for manufacturing purposes.

The quantity of water flowing in a stream is changed by the growth of population in a way that flood flows tend to increase, and dry-weather flows tend to diminish. Flood heights increase by the reduction of forest areas and of water-retentive vegetation, which causes more rapid run-offs and greater velocity in the streams. Dry-weather flows decrease in consequence thereof, because there is less time for percolation into the ground, and therefore less storage of ground-water to feed the streams in time of drought. The use of water for irrigation purposes still further reduces the stream flow, both by direct diversion of the water and by evaporation on the surface of the land.

The beds of streams, so far as they are alluvial, change in accordance with the added amount of suspended matter carried by them, and also with greater floods and their consequent scour and re-deposit of material in lower stretches of the stream.

New causes therefore appear which tend to increase deposits when velocities become less, and to increase scour when these become greater. As both effects will not exactly compensate each other at the same points, the bed of an alluvial river is constantly undergoing changes, which have increased since the advent of civilized man.

Stream beds are still further and arbitrarily changed by man when he endeavors to develop the usefulness of the watercourse, and builds dams across it, either for slack-water navigation or for power and irrigation purposes; and again when he builds or fills material into the stream, or in some way encroaches upon its natural flood section, contracting it without attention to other consequences.

All these alterations in the original conditions of a stream become the more annoying, sometimes even disastrous, by causing other results than those desired, the more a community becomes settled and developed. The objectionable results are due, perhaps, to the higher floods which now destroy more developed property, perhaps to the lower dry-weather flows which deprive water users of some of their

Mr. Hering. original ownership, and perhaps also to greater pollution of the water, tending toward unfitness for ordinary domestic, manufacturing or farming uses.

The multiplicity, as well as the seriousness, of effects upon large public and private interests caused by the streams both in their natural and artificial conditions, due to a large growth of population, is clear; some of the effects relate to sanitation, some to property rights for domestic, farming and power purposes, and some to commerce.

The National Government now controls the streams of our country, as far as they are navigable. It can regulate, dam and improve them for commerce alone. It has no control of the streams for the purposes of sanitation, irrigation or farming, for domestic and power supplies, or for any purpose of damming or contracting those that are non-navigable; nor, perhaps most important of all, has it control over the regulation of streams to prevent disaster from floods. And yet, in a developed community, these effects, while of small consequence in its early life, become of great consequence in its later life.

Reports are becoming more numerous of the ill effects of floods caused by the improper construction of dams or the change in the physical conditions upon the water-shed surface, of disasters caused by a narrowing of the flood channel or by accumulated deposit therein, or of polluted streams which have become injurious to the health and life of man and cattle.

The subject has become so aggravated in a few States that official bodies have been appointed and instructed to grapple with it in one or another of its phases.

State commissions will answer perfectly when the causes and effects are within the State. There is a clear difficulty, however, in having a single State endeavor to regulate the natural and artificial conditions of one of its rivers, when this originates in another State and is received in an injured condition, perhaps polluted, perhaps with its dry-weather flow seriously diminished or its floods increased. The other State may exhibit very little interest in the matter, and its legislature may decline to effect either the desired remedy or any remedy that had so far been suggested.

It is palpably unjust to a State, as it is to an individual, to permit a change to be made by one party to the injury of another, in the enjoyment of the natural privileges granted us by the land where we live, without a careful, impartial examination of the facts and an impartial solution of the difficulty.

While the United States Supreme Court is a proper final authority in many such cases, no court can ever be constructive, in a physical sense, and therefore will not answer the purpose now before us.

We need for this purpose in our country some Board or Commission

of Waterways, which should have supreme authority over matters relating to the physical conditions of a river from its source to its mouth, irrespective of State boundaries, consistent with and resembling the authority already placed in national hands for regulating navigable streams for commerce; an authority which can make a thorough investigation into the physical conditions, not only collecting and applying information now in the hands of various public departments, but supplementing the same with local information of special value; to study the entire subject relating to floods and droughts, and pollution and diversion of the water; to establish official profiles and cross-sections for both dry-weather and flood conditions, to which all private interests should conform; and to establish limits for the pollution and diversion of water. Mr. Hering.

The engineering work of such a body would be considerable, yet the lines along which it should be undertaken would be clear, and the results like those of similar engineering enterprises. The organization of such a body, from a legal and political standpoint, is equally important, and is a factor, perhaps, more difficult of solution. It will not be touched upon here.

The programme of the topic under discussion asks whether non-navigable streams should be under the control of the National Government. In this opening the speaker desires to take a broader view, and would add: "or of Joint State Commissions, each one controlling the water-shed of at least one large stream?" The speaker does not in the least feel opposed to a control by the National Government; in many ways it would appear to be most satisfactory. There are also good and practical reasons for having, instead, a separate commission for each large water-shed, or group of smaller ones. A local commission would be better informed concerning local conditions, which are or may be highly important, than if most all of its members resided elsewhere. In either case, it would be desirable to place upon such a board a member of the United States Engineer Corps, and a member from each of the Departments of Agriculture, the Coast and Geodetic Survey, and, perhaps, also from a Bureau of Commerce.

It seems sufficient at this time to call attention to the importance of a proper regulation of our non-tidal streams, of the physical practicability of doing this, and of the necessity of having such regulation undertaken by a body whose authority must extend over the territory of at least one entire water-shed; our whole country being divided into as many water districts for this purpose as may seem best.

As precedents for such an undertaking we may consider the following:

The Mississippi River Commission is a body which has authority over the regulation of our largest river, extending through several

Mr. Hering. States. Its authority, however, is less broad than it appears, from what was said above, might properly be given it.

Recently, a Flood Commission was established in the State of New York to report on flood preventions. The work of such a commission must be hampered to some extent by its limitations, and, unless it takes a broad view, and has authority and means to make comprehensive investigations and carry out recommendations, its usefulness to the State cannot be of the extent which is here contemplated.

In England, due partly to the more uniform and smaller rainfall and stream flows than ours, and partly to the previous attention that has been given to the question of damage by floods, these matters do not now receive very serious attention. The large industrial development, on the other hand, has compelled the enactment of laws for the government of streams, prohibiting the introduction into them of solid matter not carried in suspension, such as earth, ashes, building rubbish, sludge and solid sewage, also all liquid sewage and polluting liquid from manufactories, provided that remedies are reasonably practicable and available under the circumstances of the case. The carrying out of these laws is placed in the hands of River Conservancy Boards and Joint River Committees, each of which has control of one or more water-sheds, and in some matters acts in conjunction with the Local Government Board, which has general charge of such matters.

In France, for many years there has been a special bureau in the Department of Public Works called the Hydrometric and Flood Announcement Service (*Services Hydrométriques d'Annonce des Crues*). This bureau has studied the general conditions of each river basin, the means to prevent inundations and to regulate and equalize the flow, and sends advices when floods are expected. The water-sheds for which special Boards were instituted under the direction of the Chief Engineer of Bridges and Roads (*Ingénieur en Chef des Ponts et Chaussées*) are: Seine, Canal de la Sambre, Escault et Yser, Rhône, Muerthe et Mosel, Aune, Tech et L'Agly, Garonne, Dordogne et Adour, and Loire. Among these, the Seine, Rhône, Garonne and Loire are the most important. Quite recently, a law has been passed authorizing the Department of Hygiene to inquire into the pollution of rivers, and provide remedies. It also authorizes the protection of all sources of water supply, and imposes fines for polluting the same.

In Germany, the regulation and correction of streams is in the hands of Provincial Governments in Prussia, and the State Government in Bavaria. The smaller states agree to the treatment of interstate rivers by the adjoining countries before work is done.

Each of the Prussian provinces has a Stream Building Commission (*Strombaudirection*), with a Chief Engineer (*Oberpraesident*) at its head, which controls design, construction and operation for each river flowing through several districts, and even into adjoining provinces, so as

to obtain uniform results for the entire river. Such Commissions are located in Dantzic for the Vistula, in Breslau for the Oder, in Magdeburg for the Elbe, in Coblenz for the Rhine, in Munster for the Dortmund-Ems Canal, and in Potsdam for the Havel, Spree, Oder-Spree Canal, etc. The mouths of the rivers are controlled by another branch of the government, for political reasons. The rivers pollution questions are under the control of a Minister of the Government, advised by the Imperial Board of Health. Mr. Hering.

For information concerning European countries the speaker is indebted to Ernest Pontzen, Cor. M. Am. Soc. C. E.; Theodor G. Hoech, M. Am. Soc. C. E., and R. A. Tatton, M. Inst. C. E.

In some respects, it will seem better to have separate authorities to regulate the questions of quantity and quality of the water, speaking broadly. On the other hand, there are many intimate connections which point to a preference for a single commission controlling both hydraulic and sanitary questions. In Europe these questions are now in the hands of different bodies, both, however, branches of the general government.

With many of our larger rivers, flowing from one State into another, it seems proper and timely to obtain, as early as possible, a harmonious and intelligent treatment of their profiles and sections, and also of the questions of diverting and polluting their water. Official profiles should be established for the entire river, which will regulate the velocities, both at high and low stages, so that they will not cause disastrous results. Normal cross-sections should be established for the ordinary and also for the freshet flows. No obstructions whatever should be allowed within them, although the territory rarely flooded, but lying within the flood sections, might be used for agricultural purposes, as is sometimes done in Europe, with the risk of occasional destruction of crops. As it may often be necessary to protect wide expanses of adjoining property, some flood sections would have to be diked; and, to prevent interruption of the crossing traffic, the entire flood section between dikes would have to be bridged at the proper height. In many cases it would be advisable to alter the alignment of the stream more or less, to straighten and shorten it, where now there is meandering. In adapting such changes to the special soil of the bed, it is often also necessary to construct special submerged dams, so as to maintain the original and natural regimen of the streams.

An important duty would also be the establishment of storage reservoirs where found expedient, for the purpose of reducing flood discharges and increasing low-water flows, both of which may benefit the riparian owners by preventing damage in one case and ensuring greater usefulness in the other.

The diversion of a part of a stream should be regulated in such a manner that the water, in accordance with its value, could be properly

Mr. Hering. and justly distributed among the respective States within its water-shed, and deprive no State of water to which it has a natural right.

Where works of industry, and particularly of ore-washing, load a stream with matter that is first carried in suspension and then deposited lower down, thus raising its bed, proper means should be proposed to prevent injury to any riparian rights without unjustly interfering with important industries.

And lastly, such an authority as above suggested could establish regulations regarding the pollution of water from source to mouth, and thus protect it for the benefit of all users alike, whether in one State or another. It would devolve upon the same authority to determine the proper uses to which the waters of certain rivers could be put. In some cases it would be practicable, and even necessary, to reserve them for the domestic supplies of future populations; in others, manufacturing interests may abound to such an extent that certain streams should not be devoted to domestic use, but reserved for other uses, and protected only to the extent of not becoming objectionable to sight or smell.

Regarding the important matter of payment for the work herein considered, it may only be said that whether the National Government or Joint State Commissions undertake the same, it would manifestly be unfair to pay for it entirely from funds of the General Government, in districts where it is not itself a large landowner, because the benefit would accrue generally to the water-shed affected, and particularly to the riparian property owners. Payment, either by the State at large within which the improvement is made, or by the assessment of benefits against the counties or the private individuals affected, would seem more equitable.

All the subjects here suggested, and but briefly touched upon, are more or less effectively solved in the countries of Western Europe. They are now becoming more and more urgent of solution in our own country. It is to be hoped that we will not be long in arrears in crystallizing the method of handling this important subject in non-tidal streams as well as it has been handled in tidal rivers, in part by the United States Corps of Engineers, and that the results may be at least as beneficent as those accomplished across the Atlantic.

Mr. Darrach. CHARLES G. DARRACH, M. Am. Soc. C. E. (by letter).—The control of non-navigable streams involves their entire course from source to mouth. There is but little doubt that the regimen of streams passing through two or more States can be controlled by the National Government, but the individual State alone has jurisdiction over non-tidal streams wholly within its own boundaries, unless it can be shown that lack of vigilance on the part of a State works danger and damage to the health and prosperity of the citizens of another State with whom the delinquent is indissolubly united.

Present knowledge makes it possible, with slight expense, to absolutely prevent sewage pollution of streams, and the subject under discussion should take into consideration such prevention. In the writer's opinion, the aid of the General Government can be invoked to conserve the purity of any non-tidal stream, even if its entire course lies wholly inside the confines of an individual State, without violating State sovereignty, the only bulwark against imperialism. Mr. Darrach.

A State must be considered as an individual or a household in a community is considered. The individual and the household, although imperial, must be governed by the general laws of the community.

Pathogenic bacteria may be carried in the body and be voided from a perfectly healthy person, and be the source of spreading disease; so that a healthy individual may be the vehicle for carrying disease from the polluted stream of one State into that of another; and if a State refuses to preserve the purity of streams lying entirely within its own borders they may become sources of disease and danger in other States.

This subject is most important, as it deals with the life and health, as well as the comfort and wealth, of our entire country.

At present the War Department of the National Government has control of the national engineering. Does not the subject under discussion point to the advisability of a new department in our National Government dominated by civil engineers?

Francis Collingwood, M. Am. Soc. C. E. (by letter).—This subject is one with which the writer has had intimate acquaintance in connection with the streams in the "southern tier" of New York State; and, as emphasizing the remarks of Mr. Hering, he desires to cite the valley of the Chemung River, with which he has been acquainted for more than half a century. Mr. Collingwood.

A number of years ago, after a disastrous flood, which reached a higher point at Elmira than any that ever preceded it, he was called upon to devise means by which the city should be protected from future flood damage. A careful survey was made for about 3 miles of the length of the stream, with cross-sections of the stream and portions of the valley at frequent intervals. Having removed from the vicinity some twenty years before, the writer was amazed at the changes wrought in that time.

At a point about a mile below the center of the city the stream had widened from a normal width of about 600 ft. to some 1 400 ft. The banks, formerly steep and covered above with grass and trees, were cut and gashed, and there were small detached pools of water, and a growth of black alders reaching out 100 ft. in width. The stream bed, formerly clear and with no obstruction, was now a series of little gravel islands from a few square feet to several acres in area,

Mr. Collingwood. and also covered more or less with alders. In place after place every particle of the black mould had been removed from the ground, leaving a sterile waste of clay, covered with coarse weeds. This destruction was not limited to one locality; the same conditions were to be observed everywhere along the stream, and the writer was informed by a large land-owner at Wyalusing, on the Susquehanna, that the river flats, which formerly he considered his most valuable land, were now almost worthless for agricultural purposes.

The causes, in the case of the Chemung River, are not far to seek. One of the streams forming it is the Tioga River, which has a very steep descent. Formerly, the region was heavily wooded, but the timber has been entirely removed. The results are shown strikingly in one fact, viz., after a storm the floods now reach Elmira in little more than half the time they formerly occupied. The history is familiar to all intelligent observers, and need not be dwelt upon. The worst of it is that heavy floods are increasingly numerous, and the damage continuous. The converse of this, that is, the very low water in summer at present, as compared with the clear, bright, flowing river of former times, is also in evidence.

Now, as to the remedy: The design proposed was to restore the sections of the stream, by diking and dredging, in such way as to pass the largest known flood safely, and without damage to property.

The objections were, first, the cost, estimated at about $700 000; second, the fact that to this must be added a constant yearly assessment for maintenance. The improvement proposed that the material excavated should be utilized in building on each side of the river a pleasure drive. A third objection, in the writer's mind, was that the concentration of the full flood at the lower end of the improved channel, instead of its being spread over the valley as it is at present, might lead to damages to regions below, which could not be foretold.

The only result of the survey was the building of one or more dikes, which seem to have been seriously damaged in a recent flood.

A copy of the report was sent by the writer to the Governor of New York, and his attention was called to the enormous and irrevocable destruction of valuable land, and also to the fact, as outlined above, that no separate municipal or other body could with propriety undertake stream control. It could only be accomplished successfully by the State. Another remark of Mr. Hering is here to the point; the Tioga River heads in Pennsylvania, while the Chemung River is in New York.

In an article in the "Journal of Forestry and Irrigation" the effect of deforestation was shown by the record of actual observations made during the eight months succeeding April 1st, 1901, on Salt River, Ariz., below where it is joined by Tonto Creek, and on Tonto Creek half a mile above the junction. The basins are contiguous and similar, but

the Tonto Basin is heavily grazed and almost bare of timber, grass or other vegetation; while the Salt River Basin lies in the Indian Reservation, where the sheep and cattle of the white men are not allowed, and it is heavily timbered and well carpeted with grass. The Creek carried 0.00275 of 1% of sediment, while Salt River carried only 0.00146 of 1%, or only about half as much. Mr. Collingwood.

This brief statement is presented, for the reason that the facts lie wholly within a lifetime, and show how rapidly the destructive agencies act when once set in motion. There are indications that the same cycle of events is in progress in the extreme West, where some of the most heavily wooded regions are being rapidly deforested. The suggestions of Mr. Hering are wise, and to the point.

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AMERICAN SOCIETY OF CIVIL ENGINEERS.

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PAPERS AND DISCUSSIONS.

IRRIGATION WORKS.

An Informal Discussion at the Annual Convention, May 22d, 1902.*

SUBJECT FOR DISCUSSION.

"Should the National Government Undertake the Construction and Operation of Irrigation Works?"

By Messrs. ELWOOD MEAD, T. M. RIPLEY, F. H. NEWELL, GEORGE H. MAXWELL, J. JAMES R. CROES, L. M. HAUPT and CHARLES G. DARRACH.

Mr. Mead. ELWOOD MEAD, M. Am. Soc. C. E.—There are two classes of irrigation works which the National Government may properly build and operate. The first are reservoirs located in the channels of streams the waters of which are used in irrigation; the second are diversion works of great magnitude and cost. Both promote the public welfare in such manner that public opinion should favor the extension of such aid.

Reservoirs are a necessity to the largest and best use of the water supply of the arid region. There is scarcely a stream which can be fully utilized in irrigation without storing a part of its flow. This is due to the fact that streams do not rise and fall with the demand for water; they are high when but little is used and low when water is most needed and most valuable.

* The discussion of this subject, for which no formal paper was presented, is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion. (See Rules for Publication, *Proceedings*, vol. xxv, p. 71.)

Communications on this subject received prior to September 26th, 1902, will be published subsequently.

While the mountain snows are melting floods run to waste, but when the snows are gone streams shrink to a mere shadow of their former volume, and this shrinkage occurs when the needs of irrigators are greatest. The studies, now being carried on by the Irrigation Investigations of the Office of Experiment Stations, of the duty of water, when compared with the flow of streams, as shown by the gaugings of the United States Geological Survey, reveal the fact that a large part of the water supply runs to waste before it can be profitably used. Weber River, in Utah, has dropped from 4 588 cu. ft. per second in June to 455 cu. ft. per second in July. The high-water flow of the North Platte River in June has been thirty-four times as great as its low-water discharge in August. The discharge of Clear Creek, one of the irrigation streams of Northern Wyoming, in June, 1898, was 32 000 acre-feet; in July it was less than 12 000 acre-feet. Mr. Mead.

Before these facts were understood, many ditches were built to utilize the floods of spring and early summer. Much of the land under these ditches is now either idle or its cultivators often suffer severe losses. The construction of reservoirs is the only means of improving these unsatisfactory conditions. Such reservoirs will not only increase the farmed area, but add to the profits and security of the farmer, and will be worth far more than they will cost. Why, then, should their construction not be left to private capital? The answer is: To avoid legal and economic complications over water rights. Storage works located in stream channels must receive all the water which comes down from the mountains above. They intercept the water when the river is low, when it is all needed and all belongs to those having vested rights. Many of these reservoirs will be in places remote from the lands now irrigated. The farmers who need all the natural flow cannot see what is taking place, and, when they suffer from shortage, the reservoir which stands between their farm and the mountain snows, if it is a private property, will almost inevitably be held responsible. Distrust and anxiety thus roused will lead to controversy, if not litigation. All these evils will be less likely to arise if the works are public. Irrigators will be less likely to suspect interference with their rights when the works are under public control than when they are operated for private gain.

There are other reasons why these works should be public property. Where storage works are built and controlled as private enterprises, there is danger that the owners of such works will trade upon the necessities of farmers, and, when their fields are suffering from drouth, will charge such high rates for water that the prosperity of irrigated agriculture will be endangered. But if these works are built by the Government, the tendency will be to make water rates reasonable and stable. The doctrine of public ownership can be maintained over the stored supply as well as over the natural flow. Monopoly of water will be impossible, and its abuses averted.

Mr. Mead. The argument for public reservoirs, therefore, is not that private capital cannot afford to build them, because recent experience has shown that many of these works can be made highly profitable, but that they should be regarded as a public utility, just as we regard bridges across streams on public roads. There is no question that toll bridges on many highways would pay, and there is equally no question that while they would be profitable to their owners they would be a nuisance to every one else. That, it is believed, would be the experience with many private reservoirs located on running streams.

The construction of costly diversion dams and main canals on large rivers, by the Government, is justified by the fact that the United States owns large tracts of land, now practically worthless, but which could be made habitable and productive by this outlay. If ownership carries with it responsibility, then it is the duty as well as to the interest of the Government to administer this property so as to make it provide the largest possible opportunities for those seeking homes on the public domain. To say that the Government shall take the attitude of an alien landlord who makes no improvements and pays no taxes, is not an enlightened conception of its duty, nor is it just to the arid states.

Neither individuals nor corporations will undertake these works unless there is a prospect of a profit commensurate with the risk. If this profit is realized it will put the cost of these lands beyond the means of poor men, who are the ones to be looked after in the disposal of the public domain. Only the well-to-do can buy land which costs from $15 to $25 an acre for a water supply.

The Government can better afford to do this work than can private enterprises, because the Government derives an indirect return which private enterprises cannot share. Every acre of land reclaimed adds to the taxable wealth and to the greatness and strength of the Nation. These benefits will be unending, and will increase with time. They are worth the outlay required.

It is proper that the Nation should build these works, because some of them will be located in one State while the water will be used in another State. It will be a much simpler arrangement to have this work done by the National Government than for the States to reach an agreement. Some of the States are too poor to utilize their resources, some are prevented by constitutional restrictions. The National Government can secure the needed funds from the sales of public lands, and build these works without any burden to taxpayers, East or West. The States have no such resource. They cannot even tax the public lands, which in some States comprise more than 80% of the total area.

There are also some vexed questions relating to the respective spheres of State and National authority over the control of streams

used in irrigation. Each State now controls the division of water within its borders, and should continue to do so, but there is need that this control shall be more effective, in order that controversies may be averted and the rights of actual users of streams made secure. In order to do this, the field of control of the Nation and of the State must be known. We are beginning to realize that the framing of water laws is among our most vital and perplexing problems. Many of the streams of the arid region finally flow into navigable rivers, and the question arises: Is the steamboat below or the orchard and garden above to have first claim on the mountain snows? There are interstate streams where on one side of a State boundary the doctrine of appropriation prevails, and on the other side the common-law doctrine of riparian rights. How are they to be reconciled? These questions will sooner or later press for a final settlement, either through legislation in Congress or by litigation in the Supreme Court of the United States. They involve the best use of resources of great value, and vitally affect the material development of one-third of the United States. Mr. Mead.

The construction and operation of irrigation works of the character above described, by the Nation, will tend to promote the enactment of more uniform and better laws by the States; it will help to educate public sentiment regarding the legal and economic problems which irrigation development is creating, and, in the end, make the arid region a more valuable and prosperous part of the Nation than if development is left wholly to private enterprise.

T. M. Ripley, Assoc. M. Am. Soc. C. E.—In speaking of this subject, at first thought, it seems that the fundamental idea is the wide-open policy of our Government in regard to emigration. Knowing this, and having lived for five years on the eastern slope of the Rocky Mountains, in Montana, there seems to be but one answer, viz., "Yes." Yet this answer must be qualified to include only that portion of the question which would deal with the building and operation of storage reservoirs. Such reservoirs would be interstate in their character, from the fact of their influence, not only on that portion of the stream above, but also on the government of the flow below them. Mr. Ripley.

The cost of such works, the fact of their influence passing state boundaries, the effect which, in many cases, they would have upon the flow of streams now under the control of the Federal Government, as well as the operation and maintenance of the same (they touch the very life of the land-owner in the arid region), make it not only expedient, but actually imperative, in some of these cases, that these works be those of the General Government.

On the other hand, it may and probably will be found more expedient that federal control should end at the river gate, and all ditches with their accompanying works be owned, operated, and maintained

Mr. Ripley. by those purchasing the water. Control of this water by sale, its proper apportionment to the land, and some restriction, so that the water cannot be bought for a speculative purpose, are absolutely necessary for the bringing of the maximum acreage under irrigation.

The quantity of water stored is always obtainable, the acreage possible to irrigate always known, and the former must serve as much of the latter as possible, to fulfill its duty.

What is to be done with the emigrants after receiving them within our borders, is a pressing question, the answer to which has heretofore been "Send them West." But the West is becoming filled up. Now, that may sound strange to a great many who know that they can ride for miles and miles along a river course, and even for days across country, seeing only a few log cabins; nevertheless, it is true. The country is becoming "filled up," for the simple reason that it has all the population it can at present support economically, from the very fact that there is not enough water, or that the water in the locality cannot be used.

Go to the headquarters of many of the mountain streams; follow them for miles, and what do you find? A few ranches located on the lowest of bottom lands, each ranch with a few irrigated acres; the remainder is "range," and, if the stream is small, few years go by without a "water fight." The man below, suffering from want of water, blames his neighbor further up stream, and this in the face of the fact that his fields are scarcely dry from the spring freshet of a few weeks before.

The Government is an owner and dealer in land, and, as was said before, it encourages the emigration of people to those lands. The current reports show that the number of emigrants will be greater this year than in any previous year, and to give a man an unirrigable quarter-section on which to build a home is like offering a stone for bread.

An article* by Mr. Elwood Mead begins: "Although one-third of the United States is arid, the importance of its reclamation and settlement to the Nation has thus far been disregarded."

Mr. Mead's statement is too sweeping. The Government has made surveys for dam sites and maps of the same, yet, so far as known, the matter has been carried no farther.

Moreover, legislation is now pending, and let us hope that something of real value to this large region may be accomplished. There are thousands of acres thirsting for the water which will place them among the most fertile in the world; square miles of virgin soil, the value of which will increase from 500 to 1 000%, when properly irrigated.

That the Government will build and own the great works which are necessary for the reclamation of this land, is, let us believe, the

* *The Outlook*, April 12th, 1902.

hope of everyone who is interested in our great arid region. Let the water, now making torrents and flooded rivers, be stored and sold at a just rate; then the land, now producing only sage brush, cacti and bunch grass, will be changed from cattle ranges into farms. Mr. Ripley.

Again, many good ranges and winter shelters have to be abandoned, and the cattle driven many miles to lower ground, or else may perish on the range for lack of food, when, with a proper storage and application of the run-off, the necessary amount of feed could be produced on the ground now abandoned. Should this work be once fairly started, it will so demonstrate its own value that nothing will stop it. It means a new West; a doubling of our resources.

F. H. Newell, M. Am. Soc. C. E.—The direct answer to this question lies now with statesmen, rather than with engineers, as such, since it is a matter which has been discussed from many standpoints for half a generation, and has entered into national politics to the extent at least of being embodied in the platforms of all the great political parties, and has formed a considerable portion of the recent Message of the President to Congress. Since the Chief Executive of of the Nation has answered the question in the affirmative it would not be in accord with official courtesy to take the opposite stand, even though it might accord with personal ideas, which in the present case it does not. Mr. Newell.

Under the circumstances, it might be considered preferable at the present time to discuss, not the question whether the Government should undertake the construction and operation of irrigation works, but rather, what are the limitations, or the extent to which the National Government should go into the matter. The developments within the arid region, through private enterprise, have proceeded to a point where the construction of large works, as a rule, is found to be impracticable from the financial standpoint. Many small works have been built and have been found to be successful, both in an engineering sense and in affording a satisfactory revenue; but the opportunities for building such small works have nearly all been utilized, and further development rests largely upon the question as to what shall be done toward storing floods or diverting large rivers.

The situation, as regards the vacant public lands and the opportunities for the reclamation of arid areas, has for many years been one of the matters for examination by the United States Geological Survey. It may not at first glance be apparent why this organization is concerned with the matter. The word "geology" to some engineers is synonymous with rock structure, or hypotheses as to the origin of veins and mineral deposits. The word, however, has a far wider meaning, and by geologists, at least, is made to include a thorough knowledge of the earth's surface, its history, pres-

Mr. Newell. ent condition, and even the study of the natural resources upon and under the surface.

The Geological Survey is something more than the examination of the structure of rocks. In fact, its organic law demands that the Director shall have charge of the classification of the public lands, and examination of the geological structure, mineral resources, and products of the National domain. The necessities of land classification and mapping the resources have given rise to extensive surveys and engineering investigations, so that in classifying the officers or members of the Geological Survey it may fairly be said that fully one-half of this corps consists of engineers, as distinguished from geologists. The Director himself, although not claiming to be an engineer, has a well-earned reputation, not only as a scientific man, but, among an entirely different group of men, is known as one of the best designers and constructors of large buildings.

The explorations made by the Geological Survey in its early days attracted the attention of the public and Congress. In particular, the work of its former chief, John W. Powell (Director from 1880 to 1894), called attention to the importance of irrigation. In 1888 he was authorized by Congress to ascertain the extent to which the arid lands could be reclaimed by irrigation, to survey reservoirs and ascertain the cost of construction.

Elaborate plans for reclamation were made at this time, but the irrigation survey thus created had a short life, terminating in 1891, its work being continued on a small scale by what is known as the Division of Hydrography of the Geological Survey. Congress, however, apparently never gave up wholly the idea of Government work, since, in the various acts passed from time to time, the interest of the Government has been guarded, and in all land titles right-of-way for works constructed under the authority of the General Government has been reserved, and reservoir sites have been segregated on public lands.

The amount of water available for storage and for diversion has been the subject of study year after year by the Division of Hydrography, and data bearing upon this question of ultimate reclamation have been brought together. At the same time, a study of the public lands has been made, maps have been prepared showing the location of these, and illustrating the vast extent of land in each state and territory still in the hands of the General Government.

As a result of the information brought to the attention of the people, there has grown up a popular movement for the reclamation of the arid region. This has found expression in the organization of a body known as the National Irrigation Association, composed of influential business men, not simply of the West, but of the eastern

or manufacturing portions of the country. These men appreciate that the development of the western half of the country rests wholly upon irrigation, and that the West when completely developed will be the best market for the products of the factories of the East and the cotton fields of the South. The men who have investments in railroads also appreciate that their prosperity is closely linked with that of the growing West, since the earnings of the railroads and of the men whose goods they haul are dependent largely upon the amount of material carried backward and forward between the East and the West. Mr. Newell.

Notable opposition to this movement has come from only one source, and that is the eastern grange. There has been a fear that by the building up of homes in the West the agricultural lands of the East will be depreciated in value. A careful examination, however, shows that there is no competition of farm products East and West, but, on the contrary, the crops raised under irrigation are of different character and find another market than that of the humid East or the well-watered Mississippi Valley. The actual condition is just the reverse of that feared by some of the eastern farmers. For every acre brought under cultivation in the West there will be an acre cultivated in the East to supply food to the laborers in the manufactories or on the railroads furnishing the western farmer with the implements and articles for his home and farm.

The agitation which has continued has resulted in the bringing forward of many bills authorizing Government construction, one of which has already passed the Senate, has been informally, but favorably, considered by the President, and is now before the House of Representatives with, it is claimed, a majority pledged to its support. The question, therefore, as to whether the Government shall undertake the construction and operation of irrigation works will probably be answered in the affirmative within a few days by the House of Representatives.

In the meantime the executive officers of the Government have not been idle in collecting information for use in connection with proposed works. Extensive surveys have been carried on and plans have been made for a number of structures, so that, whenever money is available, work can be begun toward carrying out the wishes of Congress. The various projects now under consideration, and the detailed plans for some of these, can be seen at the office of the Geological Survey, and it is hoped that engineers interested will visit the office and inspect the results of some of the work.

In addition, detailed facts concerning the present condition of irrigation development have been collected by the Census Office, another bureau connected with the Department of the Interior, but entirely distinct from the Geological Survey, excepting that experts from the

Mr. Newell. latter have been detailed to the Census Office for specific purposes. The Eleventh Census, 1890, was the first to take cognizance of irrigation.

The Twelfth Census, 1900, has continued the investigation, and there are now in the hands of the Government complete schedules showing the farm areas and values, and the detailed crops for every farmer in the United States. In addition, schedules are on file for most of the irrigators of the West, and detailed statements concerning ditches, canals and investments made in irrigation works. Without going into the subject, it is sufficient to state that the total area irrigated has increased from about 3 500 000 acres in 1889 to more than 7 000 000 acres in 1899, or 103 per cent. The number of irrigators in the same time has increased from about 52 000 to 102 000, or 95 per cent. The total cost of construction of the irrigation systems now in operation has been estimated at $64 000 000.

There is a tendency to greatly exaggerate the extent and value of the present irrigation developments. The statements given out from time to time by various parties would lead to the conclusion that the arid region is far more largely reclaimed than is shown by these figures. The census examination, however, has been made and checked in a very thorough manner, the enumerators' returns having been gone over with great care and compared with information obtained through correspondence and field examination, so that they are supported by a wealth of collateral evidence. To illustrate this point: It is popularly stated that in Nebraska more than 1 000 000 acres have been brought under irrigation within the last ten years. The detailed enumeration by the census failed to find anything like this acreage, and the field examination and correspondence revealed the fact that thousands of acres of the lands claimed to be irrigated have never been actually watered. In fact, less than 150 000 acres have been irrigated successfully, or not much more than one-tenth of the amount claimed. In the same way the mileage and cost of existing ditches fades away under a careful scrutiny, and many of the conclusions drawn, as regards conditions in the irrigated region, are found to be fallacious under the careful scrutiny of impartial statisticians. This point is emphasized because it is sometimes asserted that irrigation development in the West has already been completed by private enterprise, and that the Government should have no further interest in the matter.

On the contrary, the Government is still the great land-owner, having control of from one-half to nine-tenths of the area of the arid states, and, through the recently adopted policy of forest reservation, it is taking active steps to preserve and perpetuate the water supply, and, through the legislation now in hand, it is probable that it will continue in the line of reservoir construction and diversion of large rivers.

GEORGE H. MAXWELL, Esq.*—This discussion brings up two points to which attention should be directed. Mr. Maxwell.

The question under consideration is:

"Should the National Government undertake the construction and operation of irrigation works?"

When that question has been decided in the affirmative, the next question, and a very important one, is how to get the National Government to do it.

When the matter is presented to Congress, the question is immediately asked: What return will the Government get for the expenditure of its money? In answering this question it is essential to bear in mind that there are two specific propositions to be considered, and that they must always be kept separate and distinct, and never confused.

One question is: Should the National Government build the storage reservoirs to conserve the flood waters that now go to waste, in order primarily to regulate and equalize the flow of the rivers?

The other question is: Should the National Government build the reservoirs and main-line canals which are necessary to bring water within reach of settlers, in order to make possible the reclamation and settlement of the arid public lands?

The National Irrigation Association answers both these questions in the affirmative, and states them separately, among the objects of the Association, in its Constitution, as follows:

"Section 2.—The preservation and development of our national resources by the construction of storage reservoirs by the Federal Government for flood protection, and to save for use in aid of navigation and irrigation the flood waters which now run to waste and cause overflow and destruction."

"Section 3.—The construction by the Federal Government of storage reservoirs and irrigation works wherever necessary to furnish water for the reclamation and settlement of the arid public lands."

President Roosevelt, in his message to Congress, recommends the adoption of a broad and comprehensive national forestry and irrigation policy by the National Government, and the distinction between the two propositions in question is clearly drawn in his message.

Concluding that part of his message which relates to forestry, he says:

"The forests are natural reservoirs. By restraining the streams in flood and replenishing them in drought they make possible the use of waters otherwise wasted. They prevent the soil from washing, and so protect the storage reservoirs from filling up with silt. Forest conservation is, therefore, an essential condition of water conservation."

Passing from the subject of forestry to the question of storage reservoirs for water conservation and river control, he says:

"The forests alone cannot, however, fully regulate and conserve the waters of the arid region. Great storage works are necessary to

* Executive Chairman, The National Irrigation Association.

Mr. Maxwell. equalize the flow of streams and to save the flood waters. Their construction has been conclusively shown to be an undertaking too vast for private effort. Nor can it be best accomplished by the individual states acting alone. Far-reaching interstate problems are involved; and the resources of single states would often be inadequate. It is properly a national function, at least in some of its features. It is as right for the National Government to make the streams and rivers of the arid region useful by engineering works for water storage as to make useful the rivers and harbors of the humid region by engineering works of another kind. The storing of the floods in reservoirs at the headwaters of our rivers is but an enlargement of our present policy of river control, under which levees are built on the lower reaches of the same streams.

"The Government should construct and maintain these reservoirs as it does other public works. Where their purpose is to regulate the flow of streams, the water should be turned freely into the channels in the dry season to take the same course under the same laws as the natural flow."

Then he takes up the question of the reclamation of the arid public lands, and considers it as a separate and distinct problem, as it always should be considered, and, in reference to that, he says:

"The reclamation of the unsettled arid public lands presents a different problem. Here it is not enough to regulate the flow of streams. The object of the Government is to dispose of the land to settlers who will build homes upon it. To accomplish this object water must be brought within their reach.

"The pioneer settlers on the arid public domain chose their homes along streams from which they could themselves divert the water to reclaim their holdings. Such opportunities are practically gone. There remain, however, vast areas of public land which can be made available for homestead settlement, but only by reservoirs and main-line canals impracticable for private enterprise. Their irrigation works should be built by the National Government The lands reclaimed by them should be reserved by the Government for actual settlers, and the cost of construction should, so far as possible, be repaid by the land reclaimed. The distribution of the water, the division of the streams among irrigators, should be left to the settlers themselves, in conformity with state laws and without interference with those laws or with vested rights. The policy of the national Government should be to aid irrigation in the several states and territories in such manner as will enable the people in the local communities to help themselves, and as will stimulate needed reforms in the state laws and regulations governing irrigation.

"The reclamation and settlement of the arid lands will enrich every portion of our country, just as the settlement of the Ohio and Mississippi Valleys brought prosperity to the Atlantic States. The increased demand for manufactured articles will stimulate industrial production, while wider home markets and the trade of Asia will consume the larger food supplies and effectually prevent western competition with eastern agriculture. Indeed, the products of irrigation will be consumed chiefly in upbuilding local centers of mining and other industries, which would otherwise not come into existence at all. Our people as a whole will profit, for successful homemaking is but another name for the upbuilding of the nation."

The broad distinction between the two propositions; storage reservoirs for river control on the one hand, and reservoirs and canals for the reclamation of the arid public lands on the other hand, is in the nature of a return which the Government will get for its investment, and the way in which that return will come back to the Government. Mr. Maxwell.

Where reservoirs are built for river control, the return to the Government will be indirect from the increased prosperity and population of the country, and the resulting increase in our commerce and in the general welfare of the people, which will correspondingly enlarge the general revenues of the Government. It is from this indirect source that the Government gets the return which warrants the construction of any other river or harbor improvements, such as the reservoirs which have already been built on the head waters of the Mississippi River, the levees on the Mississippi River, the Eads Jetties at the mouth of that river, the Sault Ste. Marie Canal and Locks, and many other instances of river improvements which might be given.

Where reservoirs or large main-line canals are built to bring water within reach of settlers on the public lands, the Government would get its return directly from the lands reclaimed. The public lands to be irrigated would be reserved for actual settlers only under the Homestead Act, and each settler would pay to the Government his relative proportion of the cost of the irrigation system. This would be a charge on the land, just as in the case of an assessment for a local public improvement.

If the proposed National Irrigation Act now pending in Congress should be enacted into a law, it would carry into effect the policy advocated by the National Irrigation Association, and recommended by the President in his Message, for the reclamation and settlement of the arid public lands, through the construction, by the National Government, of the great reservoirs and main-line canals necessary to enable settlers to irrigate and reclaim those lands.

Under this proposed act, this would be accomplished without imposing any burden of taxation at all upon the people at large. The act proposes to set apart the proceeds from the sales of public lands in the arid and semi-arid States as a revolving construction fund in the Treasury of the United States to be expended by the Secretary of the Interior in building irrigation works for the reclamation of other public lands. When these other public lands have been reclaimed, and the cost of their construction has been returned by the settlers who have secured the lands, the money goes again into the reclamation fund to be reinvested in the construction of new irrigation works.

The amount which would be available, under the act, on June 30th, 1902, would be about \$6 000 000. To this would be added each year the estimated receipts from public lands, amounting to about \$2 500 000 a year. This would provide a fund of \$25 000 000 for construction in the first ten-year period. The average annual returns from public

Mr. Maxwell. land sales would probably increase as the country settles up, because of the greater demand for mineral land, oil land, timber land and grazing land. But, assuming that the annual returns continued at $2 500 000 a year, there would be another $25 000 000 from this source for investment in the second ten years, and the $25 000 000 invested in the first ten years would come back for reinvestment in the second ten years, making a total of $50 000 000 available for investment in new irrigation works in the second ten years. In the third ten-year period, another $25 000 000 would be available from land sales, and the whole $50 000 000 invested in the second ten years would come back for reinvestment during the third ten years, making a total of $75 000 000 available for investment in new irrigation works in the third ten-year period. It is therefore a conservative estimate that $150 000 000 would be available for investment in new irrigation works under this proposed act within thirty years from this time, and every dollar invested finally comes back to the Government.

Every safeguard which could be suggested has been embodied in this bill. It is essentially a bill for the benefit of the home-maker as against the land speculator. Lands to be reclaimed are to be withdrawn by the Secretary of the Interior, and cannot be entered except under the Homestead Act. The Commutation Clause of the Homestead Act is made inapplicable to land located under this act. Five years' actual residence is necessary before title can be secured from the Government. Non-resident owners, of lands under the system which have passed into private ownership, cannot secure a water right under any circumstances, and resident owners, or those living near the land and farming it, as in the village farm communities of Utah, can only secure a water right for 160 acres of land. Beneficial use is made the basis, the measure, and the limit of all rights to water under the act, and water rights are made appurtenant to the land.

As an illustration of what can be accomplished under this act, we may form some conception in imagination by looking at a single State. The State of Montana is as large as Illinois, Indiana and Ohio taken together. Those three States have a population of more than 10 000 000. Montana has a population of only about 250 000. If all the irrigable public lands in the State of Montana which could be irrigated from the water which now runs to waste were reclaimed by the construction of irrigation works, under this National Irrigation Act, Montana could be made to sustain as large a population as Illinois, Indiana and Ohio, and to produce equal to those States in their vast agricultural products. The Asiatic market would take every pound of surplus farm products from Montana, and no competition with eastern agriculture would be created. The demand for every manufactured product of our eastern factories would be enormously stimulated, and every section of the country would be benefited by the wide dissemination of the new wealth created in Montana. The Government would get back every

dollar that it invested in irrigation works, from the settlers who located the land. Mr. Maxwell.

It would be difficult for the human mind to devise anything which this government of ours could do which would promote the general welfare of the people as much as such a transformation as this of one of our western States. And when it is considered that Montana is but a single State, and that the whole West is capable of this same transformation, some idea may be formed of the vast potentialities of the national policy which will be inaugurated with the passage of this National Irrigation Act.

In the second question under consideration—the building of reservoirs for river control—the subject of the return to the Government must be approached from a different point of view.

As the President has said in his Message, the building of such storage works in the arid region would be merely an enlargement of our present policy of river control.

The River and Harbor Act of June 3d, 1896, contained the following item of appropriation:

"For the examination of sites, and report upon the practicability and desirability of constructing reservoirs and other hydraulic works necessary for the storage and utilization of water, to prevent floods and overflows, erosion of river banks and breaks of levees, and to re-enforce the flow of streams during drought and low-water seasons, at least one site each in the States of Wyoming and Colorado."

Under this appropriation, Captain Hiram M. Chittenden, M. Am. Soc. C. E., was detailed to make the investigation, and his report is known as the Chittenden Report.*

The report is a most exhaustive examination and discussion of all the conditions out of which the necessity for the construction of federal reservoirs grows, besides the detailed plans and estimates of the particular reservoir sites surveyed. One of these proposed reservoirs, near Laramie, Wyoming, has the enormous capacity of over 900 000 acre-feet of water.

After fully setting forth the reasons why it is impossible that these great reservoirs should be constructed by private capital or individual enterprise, and showing clearly the reasons why they should be built by the nation rather than by the State, the report closes (page 58) with the following:

"The foregoing examination has led up to the following conclusions:

"First.—A comprehensive reservoir system in the arid regions of the United States is absolutely essential to the future welfare of this portion of the national domain.

"Second.—It is not possible to secure the best development of such a system except through the agency of the General Government."

* H. R. Doc. 141, 55th Congress, Second Session.

Mr. Maxwell. One of the strongest arguments in favor of the construction of such storage reservoirs by the Federal Government is clearly stated by Captain Chittenden in this report as follows:

"There seems to be a well-nigh universal consensus of opinion that the preservation of the forests of the arid regions is distinctly a Government duty. Considerable appropriations have been made for the surveys of proposed reservations, and ways and means for their preservation are being considered. Now, one of the great arguments always advanced in favor of forest preservation is the influence which forests are supposed to have in conserving the flow of the streams. Inasmuch as the commercial value of these forests is practically insignificant, except for furnishing fuel and rough timber, the water question is really the more important one. If it is properly a Government function to preserve the forests in order to conserve the flow of the streams, surely it can not be less a Government function to execute works which will conserve that flow even more positively and directly. Granting all that can be said of forests in this connection, they certainly can never prevent the June rise, and it is precisely this waste flow which reservoirs will help to save. The forests ought unquestionably to be preserved, and the Government is the proper agency to do it, but the principal arguments therefor apply with accentuated force to the construction of reservoirs."

No one familiar with the conditions in the West would question for a moment the proper and constitutional connection between such works of river improvement as we are now building and reservoirs to hold back the waters which now run to waste in floods. This can be illustrated by what the Government is doing on the Sacramento River, in California. That river is a navigable river. In 1849 and 1850 ships which had gone around the Horn sailed up the Sacramento River as far as Marysville. The channel of the river has been filled up with silt and débris from the hydraulic mines until flat-bottomed steamers are the only craft which can navigate it, and they have much difficulty during the low water of the summer season. There are two seasons of flood on the river, one during the winter months, from the rains in the mountains, the other during the spring, from the melting snows of the Sierra Nevada.

The National Government has appropriated and is now expending several hundred thousands of dollars in the attempt to control the débris problem and preserve the navigability of the Sacramento River. The State of California has appropriated a like amount, and the money is being expended under the joint supervision and control of the officers of the State and National Governments, who are working together in the most perfect accord and harmony.

The spring flood of the Sacramento River is usually the most serious. It comes very near to the tops of the high levees that protect the Cities of Marysville and Sacramento, and on the western side of the Sacramento Valley it overflows the banks of the river and broadens out through a wide shallow channel called the "Trough," and every year overflows and practically destroys the productiveness of many

thousands of acres of the most fertile land of the Sacramento Valley. Mr. Maxwell. Any one who has traveled on the railroad from Sacramento to Woodland during one of the spring floods of the Sacramento River will remember the inland lake which is caused in that section of the country by this overflow.

There is no other way to control this overflow, and control the floods which will otherwise continue to bring down great volumes of silt and débris and fill up the channel of the river, or to permanently preserve the navigability of the Sacramento River, except for the National Government to take hold of the problem in a broad and comprehensive way and build great storage reservoirs in mountain valleys and in the basins among the foot-hills of the Upper Sacramento Valley, coupled with great main-line canals, skirting the foot-hills on each side of the Sacramento Valley, through which these flood waters can be drawn off and controlled.

A great overflow channel with well-defined banks could be constructed through what is now called the "Trough," so as to confine the water within fixed boundaries in that section. This artificial channel through the "Trough" and the main-line canal on the western side of the valley would debouch into the salt marshes of Suisun Bay, and all the silt and débris and sediment, instead of flowing down the river channel and destroying its navigability, could be deposited over wide areas of these salt marshes, which would gradually by this means be reclaimed and made productive for agricultural or grazing purposes.

The cost of this work, of course, would be great, but the speaker believes that the benefits from it to the National Government, in proportion to the amount expended, would be as great or greater than those from any other public work of this character ever built by the Government. The cost of such works must always be measured by the results. The Sacramento River Valley is one of the richest and most fertile regions of the earth. Climate and soil have there combined, over the greater part of the valley, to create every condition necessary for the support of a dense and prosperous population, if the problem of the control of the Sacramento River and its floods can be solved.

It is quite true that the lands which would be benefited by these works would not be public lands, any more than were the lands which were benefited and protected from floods by the Government levees along the Mississippi River. The conditions on the two rivers, so far as the relation of the National Government to the problem is concerned, are very similar. The benefits to the National Government would be indirect, but they would be more than adequate to justify this great public improvement.

The State is powerless to act alone in the matter, because the

Mr. Maxwell. Sacramento River, being a navigable stream, is under the control of the National Government. But there is no doubt, if this work were to be undertaken by the National Government, that the State would co-operate with it and bear a share of the cost of the works, just as it is now bearing one-half the cost of what is being done to control the débris and preserve the river channel by make-shift methods.

The idea of a large main-line canal from the Sacramento River, leaving the river at the head of the valley and skirting the foot-hills on the east, is not a new one. A commission of able engineers was appointed by General Grant, in 1874, to investigate the irrigation resources of California, and the map published with their report shows such a proposed main-line canal, extending clear down to the lower end of the San Joaquin Valley. Such a canal in the Sacramento Valley would serve a double purpose. It would aid in controlling the floods of the river, and in the protection of its channel, and water from the canal could also be used for the irrigation of lands in the valley. Instead of this being an objection, from the point of view of creating reservoir capacity, it is an added reason for the use of the water. An irrigated region of country, when it becomes saturated with water, is in fact nothing more or less than an immense reservoir. The water taken out in the canal seeps into the ground, saturates it like a great sponge, and feeds it gradually back into the stream or river below, in the summer season, at the time when the water is most needed for navigation.

The amount of water which land will hold in suspension may be illustrated by an incident in the Salt River Valley in Arizona. Experiments, made at the agricultural experiment station there, show that in sandy soil a peach orchard absorbed during the winter months 10 acre-feet of water, which soaked down into the ground and so saturated it that the orchard needed no summer irrigation. The Tonto Basin Reservoir on Salt River is one of the largest and finest reservoir sites probably in the world. It will hold approximately 800 000 acre-feet of water; and yet that whole 800 000 acre-feet of water could be soaked into less than 100 000 acres of the lands of the Salt River Valley.

The remarkable results of the return seepage from lands saturated with water used for irrigation are shown in many places in the West. After the country becomes thoroughly irrigated there is a return seepage into the stream, and this establishes a permanent summer flow which it would be almost impossible to secure in any other way.

If, therefore, the possibility that the waters stored by the National Government on the Sacramento River might be used for irrigation were to be urged as an argument against the building of such storage works, such an argument would rest upon ignorance of the conditions of the country and the results of irrigating lands. Instead of de-

tracting from the value of a system of reservoirs built primarily for the improvement of navigation, and to regulate the flow of the river and preserve its channel, the use of the water for irrigation would improve and increase the effectiveness of a comprehensive storage system for these purposes on that river. Mr. Maxwell.

If it is conceded, as all do now concede, that the Government has the power, and that it is the proper function of the National Government to build débris dams, to dredge the channels, to excavate cut-offs, to remove snags, to straighten channels, and to do the many things which it is now doing in its efforts to preserve the navigability of the Sacramento River, surely there can be no question as to its power, or as to the advisability of its going to the root of the evil and removing its cause, by building a comprehensive storage system, which would in fact and in reality accomplish the desired end. and which cannot be accomplished by present methods. And, if that be so, the speaker cannot see how it can be seriously argued that it is not a proper enlargement of the policy of the Federal Government, in the regulation of rivers, to build storage reservoirs. That fact being conceded, then the whole question becomes one merely of advisability and of the relation between cost and benefit.

Now, so far as concerns the returns to the Government, for moneys expended in that way, the proposition must be looked at from the broadest point of view.

Taking the whole western half of the United States as an illustration:

Ten years ago the census showed a population of 4 404 000 in the western half of the United States, west of the 98th meridian, and in the eastern half, 58 218 000. The census of 1900 shows a population of only 5 874 332 in the western half of the country, and, in the eastern half, 70 120 243.

President Roosevelt, in his Message to Congress, stated, and no one can gainsay the fact, that:

"The western half of the United States would sustain a population greater than that of our whole country to-day if the waters that now run to waste were saved and used for irrigation. The forest and water problems are perhaps the most vital internal questions of the United States."

If the broad and statesmanlike recommendations on this whole subject, by President Roosevelt in his Message to Congress, are wisely carried out, there will be as large a population in the western half of the United States in less than fifty years from to-day as there is to-day in the whole country. The population is increasing by leaps and bounds. At the average rate of increase of the past, the population will be doubled, and there will be more than 150 000 000 people in this country within thirty years. And no less a person than Ex-Secretary Gage stated, a few months ago, in a public address at Denver, that there would be a population of 190 000 000 people within fifty years.

Mr. Maxwell. Now, what revenues could the Government get from 75 000 000 people in the western half of the United States? The people cannot be put there unless the recommendations of the President's Message are carried out. If those recommendations are carried out, they can and will be put there. Now we are collecting, and have collected, in this country a revenue amounting to very nearly $10 *per capita* on a population of 75 000 000 people. Suppose 75 000 000 people are put in the western half of the United States, by carrying out a wise and comprehensive national policy of forestry and irrigation.

The National Government could collect from them in one year more money than it would ever be called upon to expend for the complete carrying out of the whole vast undertaking of the reclamation of the arid region.

There is a point which generally seems to be lost sight of, but which should always be borne in mind, in considering the question of a return to the Government from water-storage works built as internal improvements for river control, where the cost cannot be returned from the lands reclaimed. Wherever a new population is created a new basis for national revenues is created, not only for one year but for all time to come. And it is perfectly safe to say that wherever the Government builds such works as are proposed in the Sacramento Valley it would create increased commerce, population and wealth, which, directly and indirectly, would bring into the treasury a revenue, and this, within a very few years at most, would return to the Treasury the entire original investment of the Government.

And the speaker ventures to say that the more the people of this country study this problem the more they will be convinced that there is no expenditure which the National Government could make which would so enlarge its national resources, and build up everything that goes to make this country great, as the storage by the National Government of the great floods that now go to waste in these western rivers, carrying death and destruction with them. In a few years from to-day it will be hard to find a man who will be willing to confess that he ever stood up and objected to that policy.

The question as to storage reservoirs and the regulation of the floods of great rivers is very fully covered and answered in the Chittenden Report. The whole subject is thoroughly discussed. That report, being the engineering point of view, is by Captain Chittenden, one of the best engineers in the United States Army. The speaker is unable to point to any locality in this country where lands have been reclaimed from overflow by the construction of storage reservoirs built for that purpose. One reason for that has been that, up to the present time, there has been so much land that such reclamation was not required. But with 80 000 000 people in this country to-day, and the

probability that the population will double, and that within 30 years there will be 80 000 000 more, for whom homes will have to be provided, the speaker thinks that the practicability of the proposition will be demonstrated, in the next few years, as it has already been proved theoretically by Captain Chittenden. Mr. Maxwell.

What is known as Tulare Lake, in California, has been practically reclaimed by irrigation, because, for a number of years, the water which formerly flowed into the lake has been diverted by canals from its original channels, and used for irrigation. The bed of the lake is now dry and is good agricultural land. At one time it was a large lake. The canal systems, of course, are not reservoirs, in the exact sense, but they serve the same purpose and have had the same effect upon the lake as though the irrigation systems of San Joaquin Valley had been reservoir systems.

J. JAMES R. CROES, Past-President, Am. Soc. C. E.—Before committing this Society to the advocacy of the undertaking by the United States Government of a scheme of public improvements having the scope and magnitude of the one which has been so forcibly presented by the previous speakers, definite information should be had on a few points which, so far, have not been clearly stated. Mr. Croes.

Is there in existence, anywhere in the world, an extended area of territory which at some past time was subject to devastating freshets, but is now free from injury from this cause, in consequence of the construction of storage reservoirs on the line of the streams?

Is there any well-recorded instance in Europe or America where the construction of impounding reservoirs on the upper waters of the tributaries to a great river has been effective in reducing and regulating the floods on the line of the main stream?

Is there any case known where the freshets on any stream have been prevented or materially reduced by the construction and maintenance of a series of impounding reservoirs along the course of the stream?

In general, is the proposed policy purely theoretical, or has it been tested by actual experience on a considerable scale?

The questions suggested seem to have been sufficiently answered. There is no positive evidence that lands have been reclaimed or freshets prevented along the line of rivers by the means which it is proposed to apply in this case. Until attempts have been made on a moderate scale, and some experience gained as to methods of procedure and results, it will not be expedient or justifiable for this Society to advocate the undertaking by the General Government of works which must be on a very large scale, and which will necessarily be purely experimental, at the outset.

Mr. Haupt. L. M. Haupt, M. Am. Soc. C. E.—Extending the discussion a little beyond the limits of this country, and going back to the days of Nebuchadnezzar, we find a record of a pool 40 miles square for the purpose of storing the waters of the Upper Euphrates, which was a successful work. It was afterward destroyed by Cyrus, and the country became a wilderness. Also, the pools of the upper Nile, and the lateral basins for irrigation, furnish ample illustrations of the ability to control the waters of the stream. In regard to this discussion, the speaker is in accord with the views already expressed on the subject. The systems in India and in Egypt also are proofs of the statements made by Mr. Newell in regard to the difficulty of maintaining irrigation systems at private expense as commercially profitable. Most of them have proved to be failures, and in very few cases in this country have they been successful. Therefore, from that standpoint, it would seem to become a necessity for the General Government to reclaim the arid land regions. It should be also remembered that the emigrants who go into these new sections are very poor people, and have not the means or the concentration of capital for making public improvements, and, consequently, are unable to do so. Therefore, it becomes a question of public policy and expediency rather than one of ability to carry out those works. Just before the opening of the Northern Pacific Railroad an effort was made by Herman Clarke and others to organize a large syndicate for the improvement of the Upper Yellowstone District, but it failed. In these works, therefore, it would seem to be proper for the Government to take charge, not only for its own sake, and for the control and irrigation of its own public domain, but for the relief of navigation and the storage of a supply for its rivers.

Mr. Darrach. Charles G. Darrach, M. Am. Soc. C. E.—Upon this subject, there is room for considerable discussion. In the speaker's opinion, such work can only be properly executed upon a large scale, which involves one of two methods: First, that by the National Government, as suggested; or, second, by some great trust.

Of the two evils, the speaker prefers the National Government. Although it might not be done as well, the question of politics being involved, at least the general public would have the opportunity of selecting their own physician.

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AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

THE REGULATION OF ENGINEERING PRACTICE BY A CODE OF ETHICS.

An Informal Discussion at the Annual Convention, May 22d and 23d, 1902.*

Subject for Discussion.

"Should Engineering Practice be regulated by a code of ethics? If so, how can such a code be established?"

By Messrs. George A. Soper, John A. Ockerson, Benjamin M. Harrod, J. James R. Croes, F. W. Dalrymple, Charles G. Darrach and W. Hildenbrand.

George A. Soper, Assoc. M. Am. Soc. C. E.—The question as to whether the practice of the members of this Society shall be regulated by a set of rules or standards of action, is not novel. The desirability of having a code of precepts for the guidance and control of careless or indifferent engineers, who may be over-strenuous in seeking employment, or willing to accept services which are incompatible with the dignity of the profession, is a perennial subject of discussion. Mr. Soper.

There are members of this Society who consider that the vocation of civil engineer is less remunerative and desirable than it need be,

*The discussion of this subject, for which no formal paper was presented, is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion (see Rules for Publication, *Proceedings*, Vol. xxv, p. 71).

Communications on this subject received prior to September 26th, 1902, will be published subsequently.

Mr. Soper. and that the way for engineers to improve their status is to form themselves into a more homogeneous moral whole. In this era of great industrial development we have daily reminders of the strength that lies in union. Everywhere we see harmonious working agreements based on the community-of-interests idea, the object in all cases being to reduce the inevitable friction which comes from many independent units working at cross purposes in the same field, and to reap the benefits which result from harmonized and co-ordinated action. From the great steel and steamship combinations down to the unions of laboring men, the utility of a close organization, bound by what may be called a code of ethics, is appreciated.

There is nothing new or formidable about the idea of a code of ethics, any more than there is about a list of by-laws of which, in the case of the Society, the code might very possibly become a part. Moral codes were old in the time of Moses, and have been indispensable ever since. George Washington had a reference guide of action, and Franklin, a chart of conduct. In a broad sense, the Constitution of the Union is a code of ethics, as are the various public laws and ordinances under which we live.

In a narrower sense, and the one in which we must use it here, ethics is the subject which treats of those moral acts which, though they cannot make us liable to bodily restraint, are capable of exercising a powerful influence for the good or ill of our fellow man.

It would be the object of a code of ethics to express the united voice of the Society upon such points as the following:

1.—To what extent and in what ways may an engineer advertise his services?

2.—Under what circumstances is the owning and exploitation of patents consistent with a strictly professional practice?

3.—What general principles should govern the conduct of consulting engineers toward other engineers engaged upon work?

4.—Under what circumstances should an engineer pass judgment on the work of his professional brethren?

5.—To what extent should the circumstances of an engineer's private life be allowed to interfere with his professional standing?

6.—Is it practicable or advisable that the Society should attempt to expose quacks?

7.—What acts, if any, should make an engineer liable to the censure of the Society.

If we consider that every man is a man of principle, that is, has definite ideas as to the moral consequences of his acts, and decides upon a doubtful course of action only after referring the matter to his conscience, we will see that he has a code of ethics, or moral standards, whether or not they happen to be written down. In the same way this Society, as an aggregation of moral and responsible men, has an

unwritten code of engineering etiquette. The main principles are known to all. The finer points, the nicer discriminations, are chiefly in the keeping of the older members. The majority of the young men are constantly improving their professional sensibility through experience, and rectifying their courses of conduct by the moral pattern set by the great chiefs. Here and there, there are exceptions; men who appear indifferent to their status, or, like raw recruits, are unable to discern, without help, what is expected of them. Mr. Soper.

The argument for a written code is the argument that the moral teachings of the pillars of the profession should be crystallized into such form as to be available and accessible to all, down to the last recruit. The argument against, expresses the opinion that the recruit should be left to find out for himself what is good and what is bad for him and his fellows.

As the one who has been asked to open this discussion, the speaker cannot announce himself as a warm partisan of either side. He has felt the need of knowledge of the ethics of the profession, and has set out to get it after the usual fashion. He has been an observer of courses of action on the part of some which he thought should not pass without the censure of a united engineering fraternity, and he has seen worthy members of another profession advance through a co-operation and support of their fellows which would be impossible with us under present circumstances.

If there is need of a written code of ethics in the American Society of Civil Engineers, that need should make itself felt naturally and spontaneously. A code, based on less than a practically unanimous vote of approval, would be difficult to introduce, and, in the end, might prove more of an incumbrance than a help. But, backed by a solid sentiment, a code should be a benefit.

It may be well to remind the members of some of the circumstances under which the question of a code of ethics was discussed in the Society some years ago.

The question of adopting a code came up for consideration at the Annual Meeting of the Society, held on January 18th, 1893. It was suggested that a special committee be appointed to consider the propriety of adopting a code, and, if a code was found desirable, to prepare one for the consideration of the Society. The matter was referred to the Board of Direction with the request that a definite recommendation be made by the Board to the Society at its next Annual Convention. The Board considered the matter carefully, and published a collation of arguments for and against the step. Finally, at the Annual Convention held at Chicago, in August, 1893, the Board advised that no committee be appointed to consider the question of a code. The subject was actively discussed by the members present at the convention, and the point was raised that so important a question should be

Mr. Soper. decided by a vote of the whole Society through a letter-ballot. A vote as to whether a letter-ballot should be called for on this subject was decided in the negative.

If the members feel differently to-day than they did in 1893, a practicable course of action seems clear. A motion can be made to the effect that it is the sense of this meeting that a letter-ballot be issued to determine whether a committee should be formed to consider the advisability of drawing up a code of ethics for the Society, said committee to be empowered and charged with the duty of drawing up and submitting to the Society such a code, if their decision is in the affirmative.

It is to be clearly understood that this would not commit the Society to a code of ethics, but would make possible a careful and official study of the subject, the results of which would be placed before the whole Society for its action.

The following is an abstract from the *Proceedings*, Am. Soc. C. E., Vol. XIX, January–December, 1893, pages 123–130.

"Proposed Code of Ethics.

"At the Annual Meeting, January 18th, 1893, the following resolution was presented:

"'*Resolved*, That a special committee be appointed to collect information and to consider the propriety of the adoption by the Society of a code of ethics for the profession, and to make such other recommendation as the committee thinks proper.'

"This resolution was declared to be subject to the provisions of Section 13, Article VI, of the Constitution, and was, under those provisions, referred to the Board of Direction.

"The duty of the Board in such a case is declared by the Constitution as follows:

"'The Board shall consider the resolution and report its recommendations to the Society at the next general business meeting, together with a statement of the arguments for and against the appointment of such committee.'"

"It is clear that the Constitution (Article VI, Section 13) makes it a little difficult to appoint a special committee, and requires a large approval of the Society to appoint a committee to act on any such subject. The Chair will assume that most of the members have read, or glanced at, the arguments prepared by the Board of Direction. The recommendation of the Board is on the last page.

"Is the meeting ready to take a vote on this question, or are any gentlemen desirous of speaking on the subject which is now before you for consideration?

"J. B. Johnson, M. Am. Soc. C. E.—These papers, Mr. President, have just this moment been handed us, and every one has not had time to read them.

"The President.—If it is desirable to discuss the question, the Chair will read over the recommendations, *pro* and *con*, of the Board,

and it can be taken up. It should have proper and careful consideration. Mr. Soper.

"Mr. Johnson.—Could this matter come up at the next session, Friday evening?

"The President.—No, sir; it is to be settled by a vote, requiring 'a two-thirds vote of all the members present.' That vote must be taken this evening. Perhaps it will take very little time; it will be just as well to read the recommendations of the Board.

"(Read the report as follows):

"'The Board of Direction herewith presents a statement of the arguments for and against the appointment of such committee to the Business Meeting of the Annual Convention.

"'Arguments for the Adoption of the Proposed Resolution.

"'1. The resolution is for the appointment of a special committee of this Society, to collect information and to consider the propriety of the adoption of a code of ethics, and to make such other recommendation as the committee thinks proper. This does not commit the Society to the adoption of a code of ethics, but simply proposes the appointment of a committee on this general subject. There should be no objection to the appointment of a carefully selected committee to consider the subject, and the members of the Society will certainly have larger information and be in a better position to determine as to the propriety or impropriety of the adoption of a code of ethics after the report of such a committee than without such report, the subject never having been carefully considered or presented as a Society matter.

"'2. The difference of opinion on this general subject which evidently exists among engineers is a good reason for the appointment of the proposed committee, so that the subject may be presented for further consideration and discussion in a clear and definite shape.

"'3. There seems to be some question as to whether civil engineering may properly be called a profession. A clear statement of what the word means is given by the 'Century Dictionary,' which defines a profession to be:

"'The calling or occupation which one professes to understand and to follow; vocation; specifically a vocation in which a professed knowledge of some department of science or learning is used by its practical application to affairs of others, either in advising, guiding or teaching them, or in serving their interest or welfare in the practice of an art founded in it.' The same authority adds: 'Formerly, theology, law and medicine were specifically known as *the professions;* but as the applications of science and learning are extended to other departments of affairs, other vocations also receive the name. The word implies professed attainments in special knowledge. as distinguished from mere skill; a practical dealing with affairs as distinguished from mere study or investigation; and an application of such knowledge to uses for others, as a vocation, as distinguished from its pursuit for one's own purposes. In professions strictly so called a preliminary examination as to qualifications is usually demanded by law or usage and a license or other official authority founded thereon required.'

"'This definition seems very clearly to apply to the actual facts of the practice of civil engineering. Men who have any right to be called civil engineers, and who have any right to be corporate members of this Society, do have a vocation in which a professed knowl-

Mr. Soper. edge of some department of science or learning is used in practical application to the affairs of others. If the proposed committee finds it desirable it would doubtless recommend some means of carrying out or of enforcing regulations for such of the relations of engineers to their clients and to each other as could at all be made subject to rules. At all events, it is desirable that the committee should study this subject and report to the Society.

"'4. Rules do exist which govern the relations, to each other and to the public, of men following other professions or vocations in which there are associations of the members of such profession or vocation in some respect similar to this Society. This applies, not only to the old so-called professions, but to other vocations. The dealers in stocks are subject to clear and definite rules, formulated and enforced through their exchanges. The dealers in produce are also subject to rules through their exchanges, and this is the case in other vocations.

"'5. It will be well to appoint a committee to consider whether the dignity of civil engineering and the relations of members to themselves and to the public might not be improved by the application of rules of ethics or of conduct to be adopted by this Society, as a representative body.

"'6. It seems to be a fact that civil engineers do permit themselves in some few instances to act in ways which in other professions or vocations would be generally considered improper and unprofessional acts. Such acts are contrary to the rules of etiquette which have become standard in those professions. The appointment of a committee to see whether this can in any way be remedied as regards civil engineers is desirable.

"'7. The lack of rules by which departures from the proper line and professional line of conduct can be judged affords excuses for unprofessional conduct when such conduct is based upon ignorance of, or indifference to, professional morals. The adoption of rules and principles governing the relations of engineers to each other and to their clients would restrain the unprincipled and guide the ignorant.

"'8. The fact that many engineers are engaged in salaried positions should be an argument in favor of, rather than against, the appointment of a committee to consider the possibility of a code which would add to the dignity of the profession. Those who require the services of engineers are apt to base their appreciation and estimate the value of those services upon the standing which the engineer himself takes. It is inconsistent with the function of this Society to depreciate engineering. It is its duty to endeavor to elevate it in every relation, and the appointment of the proposed committee will be a step in this direction.

"'ARGUMENTS AGAINST.

"'It is held that one may just as well assert that the other great professions are great in spite of their codes as because of them. Neither assertion can be proved. It seems to be a fact, however, that the lawyers have no formal code. Their rules of conduct are partly matters of tradition and partly of interpretation and construction, by various authoritative bodies, and form a valuable mass of professional ethics, but they have not been codified and adopted by the great Bar associations in the United States.

"'Furthermore, one of the most important medical societies of the United States, the Medical Society of the State of New York, has voted

to abandon its code of ethics. The fundamental reason for this Mr. Soper. action is summed up in these words of the president of that society: "It would comport more with the dignity of the medical profession, and would enhance the respect in which it is held by the general public, if all specific rules of ethical conduct were elided from the by-laws of the State Medical Society, and if the regulation of such matters were hereafter left to the judgment of individual practitioners influenced by the well-known consensus of professional opinion and by local custom."

"'It is believed that the architects also are without a formulated and accepted code of ethics. So we see that the professions are either without codes or are beginning to abandon them. The rules governing the transactions of the stock and produce exchanges are not analogous to what is understood by a code of professional ethics; they provide simply for the carrying out of specific contracts, many of which are not enforcible by law, but the carrying out of which is vital to the existence of the business of the exchanges.

"'It is held that it is impossible to frame a code of ethics that would cover all cases. Such a code would be too complicated and minute to be successfully administered. The code, therefore, must be merely a statement of general principles; but such statements have been made by moral teachers ever since society began, and the general principles which govern human conduct are sufficiently well formulated already.

"'A strict code would restrain those who need no restraint, but it would not be regarded by the unprincipled further than their own interests dictated. It would happen sometimes, perhaps often, that an engineer would be deterred from doing his duty to his client or to himself by a timid obedience to the code, or that he would make the code an excuse for not doing disagreeable things which reflected upon the honor or capacity of other engineers.

"'It is held that specific cases of violation of the traditions and spirit of the profession should be treated individually, each on its merits, and that this can be done, so far as the American Society of Civil Engineers is concerned, by presenting the case to the Board of Direction, or that a special body or committee can be created in the Society to perform this special function.

"'The Board of Direction recommends to the Society that no such committee be appointed.

"'By order of the Board.

"'F. Collingwood,
"'*Secretary.*'"

"The President.—The subject is now before you for discussion; what shall be done?

"Mansfield Merriman, M. Am. Soc. C. E.—As I understand the matter, the resolution that a special committee be appointed was presented at the Annual Meeting of the Society in January. I also understand that this business meeting has no power to act upon that resolution, that such a committee can only be appointed, that such a resolution can only be adopted, by the result of a letter ballot sent out to all the members of the Society, and that the question really before this meeting is whether such a letter ballot should be issued or not. Is that the question?

Mr. Soper. "The PRESIDENT.—The Chair will read the clause of the Constitution again, for the information of the members.

"(Read 'The Board of Direction shall,' etc.)

"The gentleman will see that the business is in the hands of this meeting and must be disposed of, under the Constitution.

"Mr. MERRIMAN.—I think I am correct, then, in the idea that the whole question before this meeting is, shall the letter ballot be issued?

"MENDES COHEN, Past President, Am. Soc. C. E.—The only motion that is proper to be offered, under the Constitution, is a motion from some corporate member present that such letter ballot shall be issued. If there be no such motion made, the matter rests just where it is now; if there be such a motion made, under the Constitution, the question then comes before the Society in this meeting, and individual arguments can be heard for and against it, and then a vote upon the question must find two-thirds of the corporate members present in the affirmative before such action can be taken. It is only if somebody here will make the motion.

"The PRESIDENT.—That statement is perfectly correct and in accord with what the Chair stated.

"Mr. MERRIMAN.—I move that it is the sense of this meeting that a letter ballot shall be issued. (Seconded.)

"The PRESIDENT.—It is moved and seconded that it is the sense of this meeting that a letter ballot shall be issued on the subject; the matter is now before the members for discussion.

"G. KAUFMAN, M. Am. Soc. C. E.—As this is a question of interest to all members of the Society, I don't think that a small meeting like this should vote this motion down; it would be better to have all the members vote upon this question.

"JOHN C. TRAUTWINE, Jr., Assoc. Am. Soc. C. E.—Mr. Chairman, the arguments against are directed simply against the propriety of a code of ethics, not the appointment of a committee. The first argument in favor of the resolution points out that all that is asked is the appointment of the committee. The arguments against seem to be directed against the adoption of a code, not the appointment of a committee.

"The PRESIDENT.—There certainly could be no objection to the appointment of a committee if there were no objection to the work the committee was to do. Are there any further remarks to be offered on the motion?

"ROBERT MOORE, M. Am. Soc. C. E.—Mr. President, I wish to express my hope that the Society will not take any steps looking to legislation of this kind. I think that the conduct of members of the Society can fairly be left to their intelligence and their intention to do right, and I do not think that we should be put in the leading strings of legislation of this Society in that matter. I think the arguments in the negative of this question are sound, and I hope that no steps will be taken to inaugurate a hard and fast code of ethics such as seems to be contemplated by the proposition.

"Mr. COHEN.—I would add but one word to what has already been said upon the subject. It appears to me that these codes of ethics, of which we hear so much and see so little—if you inquire you can scarcely find a written code of ethics, we do not see it in other associations—that a code of ethics must be governed by and formulated upon the good sense, good breeding and general comity of man to man. Now, as has been stated in this argument, such government will obtain—it has obtained and will obtain—among men of experience in

the profession, men who are trained, men who are educated; and when, here and there, you will find an exception, some erratic course will be taken, it will be much easier to regulate that within the Society if an extreme case arise, than to refer it to book. Ten to one there will be no case provided in the book, and then you have to go back to the Society in the end. Mr. Soper.

"The only objection to the appointment of a committee to consider such a question is that it is dangerous to the Society to present to the committee such an argument and stir up a matter within the Society which, at best, can do no good to the Society and which may result in injury. I have no idea myself that even if such committee be appointed and it discuss the subject, and a letter ballot be issued, I have no idea that the Society would deliberately adopt such a course. If the view that I hold, and that I think a great many hold, is correct, then for the Society to adopt such a thing would be dangerous; it is a great deal better that it be not adopted and not considered.

"A. Fteley, M. Am. Soc. C. E.—As an engineer of 25 years' standing in this country, I have been called upon, not only to perform regular duties, but I have very often been called to consult, alone or with others, on matters of importance; I have therefore had a great many experiences of various kinds. I have found in my case and in the case of others that a great many occasions arose in which the conduct of engineers was questioned. I have known of such cases where there was not the slightest reason for it. Those questions will arise, especially as to the relations of engineers and contractors; we know how much antagonism may arise. I have been a member of the Board a great many times. I have seen cases where the reception of a candidate into the Society has been fought by means fair and unfair. Sitting in the Board, I have seen our Secretary presenting to the Board stacks of letters against the reception of members simply because they have done certain things. Nine times out of ten we have found that such statements were made by interested parties who had an axe to grind, or who were taking their revenge upon somebody. It seems to me that if we submit a case like this to a code of ethics, in many cases the book will say nothing. We have duties to perform, and I suppose a great many of us try to perform them as well as we can. It seems to me that in cases of that kind a man must fearlessly follow the line of duty he believes he has to follow and let him stand by it or fall by it. It may happen once in a long while that a man may suffer unjustly, but in 99 cases out of 100 the man who is worthy, even though he has been attacked, will in the end triumph because he is a good man.

"I am very proud of our profession. I know one thing by my experience in public works, and it is this: If an action has to be passed by certain authorities outside of engineering, I find that there must be the signature of this one and of that one before action can be taken; while we engineers generally put our signatures to very large sums, and it means simply that the money will be paid without question. Consequently, why should we submit engineers who have such a high standing in the community to rules which will simply narrow the limits within which we are working. I believe it is an injustice; I believe it is an injury to our profession to try to bring us within such limits as this resolution contemplates.

"The professions of the law, of theology, of medicine, have been mentioned. The gentlemen who belong to these professions, before they can practice, have to be accepted by certain authorities. We are not in the line of these conditions; we have a great many

Mr. Soper. worthy men who have simply put their shingles out, and, in many cases, have made a success of it. Our profession cannot be compared to other professions. So far as I am concerned, I believe that this resolution is one that is likely to disturb the even tenor of our ways, and I emphatically say that we ought not to consider the idea of having a committee appointed for the purpose mentioned. (Question called for.)

"The PRESIDENT.—Corporate members only can vote. Understand, the question is, shall a letter ballot issue, or shall it not? A vote in the affirmative means that the Board shall ask the Society to vote on the appointment of a committee. A vote in the negative means that the whole matter is dropped here by the Convention. Those in favor of the issue of a letter ballot will please rise to their feet. (11 arose.)

"All opposed will please rise to their feet. (54 arose.)

"Eleven in the affirmative; 54 in the negative; the motion is lost."

Mr. Ockerson. J. A. OCKERSON, M. Am. Soc. C. E.—The agitation in engineering societies and in the technical press as to the propriety of a code of ethics to govern and guide the members of our profession may be taken as evidence of a desire to ennoble the calling of the engineer. It is a recognition of the fact that engineers, in this country at least, are not yet accorded the position to which they are entitled by the importance of their work and the conspicuous part they have taken in the development of the natural resources of our country. There are, however, some signs of progress in this direction.

None of the so-called learned professions is so intimately connected with the material progress of our country as is that of engineering. The engineer has always been the advance guard of civilization in the development of our western empire, and, largely through his instrumentality, a marvelous change has been wrought in a few decades, which would, ordinarily, be the work of centuries.

In the older and more settled portions of the country his work is equally important, in providing ample means of transportation by land and by water, and in many ways contributing to the comfort and safety of the people who live in our great cities.

Yet, in the face of all this, the profession is not held in that high public esteem to which it is justly entitled. This is due, in a great measure, to the fact that the public is not as familiar as it should be with the functions of the engineer, whose individuality is more or less overshadowed by the great corporation which employs him.

The education of the public up to the proper appreciation of the services of the engineer is necessary, before any great improvement in his status can be hoped for. It can never come through the establishment of any possible code of ethics. No opportunity should be neglected which will serve to bring the engineer and the public to a better understanding of one another. The engineer, on his part, should cultivate the acquaintance of men in other walks of life.

Much can be done at great expositions, by bringing the general public into contact with the work which the engineer has wrought and which emphasizes his science, ingenuity and skill. Mr. Ockerson.

Heretofore, engineering work in expositions has been somewhat obscured by being mixed up with transportation and other related matters which indeed are closely akin to it.

In the coming exposition at St. Louis, civil, military and architectural engineering and engineering pertaining to public works, will be housed together in the Liberal Arts Palace.

In the interests of the profession, as well as that of the exposition, and through your aid, the speaker hopes to secure for the several groups devoted to engineering the best examples of what the engineer has wrought in all parts of the world. With the co-operation of the engineering profession, which should be readily accorded, there will be gathered at the coming exposition a display which will do credit to the profession, and which will impress the layman with the dignity and importance of our calling. Every engineer can do something toward the realization of this much-desired result.

The speaker will be very glad if each member will take this up as a personal matter, and arrange to offer models, plans, drawings and photographs of some of his important work. It would also be well to have information as to any important engineering works which would be interesting and novel as exhibits.

Benjamin M. Harrod, Past-President, Am. Soc. C. E.—The speaker has but little to add to this discussion beyond the expression of great pleasure in hearing that part of the Annual Address devoted to the subject, and of entire concurrence in the views expressed by the President and by the Committee on Regulating the Practice of Engineering. Mr. Harrod.

Effective means already exist by which any desirable improvement of the relations of civil engineers to each other and to the public can be accomplished. The principles of professional ethics should be explained and impressed in engineering schools, and a full and clear discussion of them should form part of the Transactions of Engineers' Societies.

In this way an unwritten law will prevail, with all the authority, and more completeness and flexibility than can be given to a written code.

J. James R. Croes, Past-President, Am. Soc. C. E.—To the first question propounded, "Should Engineering Practice be regulated by a code of ethics," an affirmative answer must be given. No business, trade or profession can be successfully carried on in any community except in accordance with the ethical standards which prevail in that community. Such standards have varied, at different stages of the world's progress, and among different nations, mainly in accordance Mr. Croes.

Mr. Croes. with the different religious concepts which have prevailed in certain periods and among certain communities. Among what we consider the civilized nations of the present day, the standard of ethics is, as has been well said, embodied in the Ten Commandments of the Mosaic Dispensation and the Golden Rule of the Christian Dispensation. The application of these fundamental principles to special cases, and the interpretation of them, are matters of tradition, experience, equity and jurisprudence.

The second question propounded is: How can such a code be formulated and established? The answer to this must be that, under existing circumstances, the framing of a written law of action applicable to civil engineers alone, is impracticable.

The formulation of a code of rules which would be applicable to all cases in which doubt might arise in the mind of a practitioner of civil engineering as to what was the proper course for him to pursue, would involve the consideration and adjudication of almost every conceivable case of "conscience." Supposing, however, only a few general principles to be enunciated, those principles would have to be accepted by the persons for whose guidance they were intended, and an obligation entered into by such persons that they would be liable to some kind of penalty in case of their infringement. This would require the establishment of a court of arbitration or adjudication. Any attempt to establish such a code and such a court, by a society or association representing only a small proportion of the practitioners of the multifarious occupations embraced in the general title of Civil Engineering, could only result in ridicule and failure.

Irrespective of the outsiders composing the great mass of the professior, it is very questionable whether unanimity could be secured in the organization undertaking to frame a code. Our own efforts to frame a Constitution adapted to our needs furnish an instructive lesson in this respect. For years not a general meeting has been held at which changes or modifications or explanatory additions to our fundamental law have not been strenuously demanded by some one who was dissatisfied with or could not comprehend a clause or a provision of the Constitution. How much greater confusion of ideas might be expected if ethical and abstract questions were at issue!

But, while the promulgation of a formal code of ethics for the Civil Engineer is not practicable or desirable, there is doubtless a need and a demand for a public setting forth of some of the elementary principles which have come to be recognized by engineers of experience in the combined management of materials and men as fundamental, but which the young practitioner, who, fresh from his college halls, attempts to grapple with practical problems of design, con-

struction and management, has no familiarity with, and of which the ordinary man of business, unfamiliar with professional ethics, has little conception. The young engineer can only imbibe loyalty to those principles by association with older members of the profession, and, lacking the opportunity and too frequently the desire for such prolonged association, is apt to go astray and commit some solecism in morals, through ignorance rather than viciousness. It would be an advantage, therefore, if some civil engineer of acknowledged experience and standing would write a brief compendium of engineering ethics, from his point of view, and have it published by a standard bookseller. It would promote discussion and lead to much good. But, as has before been said, any effort to give to such a publication the status of an established law of morals would be absurd. Mr. Croes

A book of this kind might also serve the purpose of deterring clients from making to professional men propositions which may be considered either as silly or criminal, according to the point of view. There would have to be laid down some rules so rudimentary as at first glance to seem absurd. The principle, for instance, that no man can serve two masters, seems so self-evident to anyone who has been trained in the doctrines of the Talmud or the Bible, as not to need enforcement. And yet only a short time ago in a seaboard city, where a new administration, pledged to economy, had been installed and had reduced the compensation of all its professional advisers, a number of persons, not connected with the government, and desirous of having their ideas of the administration of an important department carried out, combined in an offer to pay, to a professional adviser whom they selected, an additional salary equal to that which the city would pay him, on condition of his appointment to the position. In other words, they proposed that this city official should have two masters; one, the city whose interests he was supposed to serve, the other, a half-master, with no responsibility to the taxpayers or anyone else except themselves, but whose interests he would be compelled to serve or lose his salary. And yet this extraordinary proposition, based apparently on a kind of electromotive idea of having one machine and two power-houses in different places and under separate control, was made in good faith by men who could not see that it was scandalous and abhorrent to all persons who had correct ideas regarding professional duties and responsibility, and that, moreover, the same rule might be carried out with regard to any other Association, or Club, or Hall, which might be willing to "put up the stuff" to have a city department run as it wanted it.

A rudimentary treatise on ethics might then be a good thing to have, but not as a formal declaration by this Society of what a civil engineer ought or ought not to do, to be, or to suffer.

Mr. Dalrymple. F. W. DALRYMPLE, Assoc. M. Am. Soc. C. E.—The speaker hardly understands whether it is proposed to create an engineering trust or an engineering labor union, but it seems to him that either proposition would be beneath the dignity of the profession. If a code of rules is established, it would certainly be necessary to create at least some sort of a court to administer and interpret those rules, which is thought to be undesirable and impractical.

The speaker begs to suggest that, if such a code is to be adopted, the best that could be formulated would be the Ten Commandments, with the addition of that other biblical proposition, to do unto others as you would have them do unto you.

Mr. Darrach. CHARLES G. DARRACH, M. Am. Soc. C. E.—A code of professional ethics may be expressed briefly in three words, known, or supposed to be known, and acknowledged, by any and everyone entitled to a membership in the various grades of this Society. Unfortunately, in the speaker's experience, and probably in that of many other members of this Society, ignorance of these words alone raises the question at issue; and, that the speaker may not be misunderstood, it might be well to make reference to where this rule may be found.

In an ancient compendium, which, by some singular fortuity, has been reproduced in manuscript and the press for nearly 3000 years, and is supposed to be in general circulation, one of the earliest writers, who, if the speaker's memory serves him right, was born in Egypt, enunciated the general principles. Of this incidental reference, the speaker thinks it is unnecessary to make more specific mention.

The difficulty seems to be in the application of the rule. In other words, to make the punishment fit the crime, or, probably it might be more aptly stated, to make the reward fit the merit. It would seem to the speaker that the first duty of a member of this Society, regardless of his experience and scientific attainments, is to be a gentleman, with that regard for each other member of the Society, at least, that he would expect awarded to himself. Unfortunately, this condition does not prevail. The speaker has known of cases where members of this Society have filched work from their fellow-members, have spoken in disparaging terms both of their business and scientific attainments, and, in fact, have done all that they possibly could to degrade the profession into a trade.

There was a time when to be a Member of the American Society of Civil Engineers meant more than it does to-day. In the speaker's experience, this, to a certain extent, is due to the present method of elections, or the practical exclusion of the blackball. The speaker remembers some years ago, and he thinks it was about the time of the first St. Louis meeting, that a certain person received some seven or eight blackballs. A great hue and cry was raised that a conspiracy had been raised against the individual in question. The speaker cast

one of those blackballs, and used no influence whatever in the casting of the others. The candidate under discussion had been given a position by the speaker, to a certain extent out of charity. The aforesaid candidate had hardly been warm in his position when, like Ephraim, he "waxed fat and kicked." The chief engineer, whose principal assistant the speaker happened to be, apprised him one day of the fact that the speaker's protégé was earnestly endeavoring to obtain the speaker's position, without even having the courtesy of mentioning the matter to him. Mr. Darrach.

No doubt many of our members could recite parallel instances, and it is exceedingly difficult to be obliged to practically convict a man of a heinous offence, which the present laws of the Society practically require, before he is excluded from the privilege of membership; but we are in the situation and must enact certain laws or bring attention to the various members who are not familiar with the ancient book to which the speaker has referred.

W. Hildenbrand, M. Am. Soc. C. E. (by letter).—The fact that the question of establishing a code of ethics for practicing engineers is to be discussed is in itself an indication that past experience must have shown that the conduct of some members of the profession has not always been what it should. This is not surprising, because human nature is the same everywhere and at all times; knowledge and mechanical skill do not necessarily exclude selfishness and injustice, which are found in all kinds of business and in every station of life. If it were possible to eradicate from human society the two evils of selfishness and injustice by a printed code of ethics, it would be our duty to adopt one, without a minute's delay. Such a code could be short and very simple; it could be comprised in a single sentence, like this: "Act as a gentleman, in every respect, on all occasions; be just and generous to your brothers in the profession, and do not hesitate to take the full responsibility for all your actions!" These maxims, of course, are not new; they have always existed as unwritten laws; they fit every profession and vocation, and if they were inherent to all men and had always been fulfilled, or would be fulfilled, no special code of ethics for engineers would be necessary. Unfortunately, there is no such perfection, and men have always existed who either lack the natural capacity of making a fine distinction between right and wrong, or whose better judgment and better sentiments are darkened by selfishness. The writer fears that no code of ethics would rectify the evils done by such men, because, if it is not in their nature to act justly and generously, no amount of printed regulations will be able to change their character. Moreover, it would be almost impossible to enumerate and define beforehand in special paragraphs the hundred and more varieties of forms of injustice. Certain actions may be justified in one case and con- Mr. Hildenbrand.

Mr. Hildenbrand. demnable in another. It might happen that a moral or professional injustice might be done, one that is not defined in some paragraph of the code, and the transgressor, though guilty, would have to be acquitted for not having violated the printed regulations of the code of ethics. By ethics is meant the doctrine of moral duties, and not a mere code of etiquette as to superficial outside forms of conduct on certain occasions.

While the writer thinks that it might be desirable to establish some simple forms of etiquette, not as absolutely necessary rules, but as advice or for convenient guidance, to the novice in the profession, he believes decidedly that a code of ethics for regulating engineering practice is not only useless, but, inasmuch as it can never be complete, it will do more harm than good. The true ethics are, or should be, implanted by Nature in every man; but, outside of that, the writer believes in letting everybody exercise in the broadest sense his full liberty, and not be hampered with regulations, as long as he does not interfere with the rights of another.

For determining whether any rights have been infringed, and for rectifying any wrongs done, the writer would propose, in place of a code of ethics, the establishment of a court of justice as a part of this Society. How to arrange the details of such a court of justice is a matter to be discussed afterward, but, in order to accomplish the desired ends, the court ought to be permanent; that is, it ought to constitute a special part or committee of this Society, having nothing else to do but examine and judge upon the disagreements of ethics among the members of the profession. The principal quality of this court, of course, should be its impartiality. Every member of the Society, whether chief engineer of a department or only a humble draughtsman, should be equal before the court, and have the right to present to it his real or supposed grievances. The court would examine these and give a verdict accordingly.

As it is at present, there is absolutely no redress for a member of the profession who suffers injustice of a kind which does not come under the regular civil laws. To mention only one instance: It happens, not infrequently, that an engineer is deprived of the credit due him for his work, in consequence of certain publications, in which, knowingly or unknowingly, the author attributes the merit to another person who does not deserve it. What can one do in such a case? Should he write to the papers, or publish another book on the same subject, merely for contradicting a certain statement? As a rule, this is impractical, and also inefficient; but let the matter be brought before a court of justice of engineers, who will make an official report, to the profession, of the true state of affairs, and who has the power to mete out punishment by reprimanding the transgressor, or, in severe cases, by his eviction from the Society. It would give general satis-

faction, and would do more toward establishing a true code of ethics among engineers than specifying and printing a number of arbitrary or self-evident rules. Mr. Hildenbrand.

The writer does not imagine that such a court would eradicate all injustice among members of the profession, as little as the ordinary courts are able to abolish transgressions against the civil laws, but he believes it would have a wholesome effect in reducing the violations of ethics, and in rectifying, to a great extent, the evils arising from such violations. This Society is large and powerful enough to make its court of justice generally respected.

The object of this discussion proves that the need for rectifying or bettering the ethics in the engineering profession has been felt, and the writer believes that such a need cannot be better or more efficaciously supplied than by a body of truth-loving men known as: "The Court of Justice of the American Society of Civil Engineers!"

Vol. XXVIII. AUGUST, 1902. No. 6.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

A PROPOSED NEW TYPE OF MASONRY DAM.

Discussion.*

By Messrs. H. de B. Parsons, Edward Wegmann and William B. Fuller.

Mr. Parsons. H. de B. Parsons, M. Am. Soc. C. E. (by letter).—The dam described by the author is practically a dam of uniform section reinforced by buttresses built against the down-stream face. This principle is not new, as many engineers have attempted to perfect such designs, when planning large masonry dams, in order to save yardage. As far as the writer is aware, no such buttress dam of large proportions has been constructed, as the plans have lacked the mass required for stability, or have indicated excessive toe pressures. However, exception might be made to some curved dams (such as Bear Valley) in which the abutting hillsides have replaced the artificial buttresses proposed by the author.

In order to secure stability against sliding and overturning forces, the important point is to have mass, rather than little mass mathematically placed. The forces acting against a dam are not scientifically determinable, and, therefore, their real action is still unknown.

The usual assumption is that the masonry mass is solid without elasticity, or else solid with uniform elasticity.

* This discussion (of the paper by George L. Dillman, M. Am. Soc. C. E., printed in *Proceedings* for April, 1902), is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.

Communications on this subject received prior to September 26th, 1902, will be published subsequently.

With dams of uniform profile, therefore, care is taken not to transgress these assumptions, which are known to be only approximate. Such dams are calculated on their sections, each section being strong enough, *per se*, to withstand the pressures and not require any assistance from the adjacent sections. Mr. Parsons.

The author appears to have altered these so-called standard assumptions by enlarging their scope to a point which may or may not be true. Thus, he figures the weight of the dam between centers of buttresses, and assumes that the weight will act through the center of gravity of the mass. The question arises, therefore, can the weight be considered as acting thus; or will not the weight of the buttresses alone be left to resist the total water pressure? This water pressure will surely come back through the buttresses on account of the arched form, but the writer doubts if much resisting weight will be available, outside of that of the masonry, along or near the axis of each buttress.

The cost of such a buttressed dam would probably exceed that of a dam having a uniform section, on account of the increased face work.

EDWARD WEGMANN, M. Am. Soc. C. E.—The idea of constructing a dam having a number of piers joined by vertical arches is not new. This plan naturally suggests itself for saving masonry. The Belubula Dam,* constructed in South Wales about 1898, was built in this manner. This dam has a length of 431 ft. and a maximum height of 60 ft. above the foundation. The lower part of the dam is formed of a solid wall of concrete, 23 ft. high at the lowest part of the valley. On top of this wall six brick buttresses are built, 28 ft. from center to center. The piers are joined by five elliptical arches of brickwork, 4 ft. thick at the bottom and 1 ft. 7 ins. thick at the top. The arches are inclined down stream 60° from a vertical plane, and form the upper 37 ft. of the dam. Mr. Wegmann.

In connection with the power plant of the Pioneer Electric Power Company, of Ogden, Utah, a concrete dam 100 ft. high, consisting of a number of piers joined by arches, was proposed. The design of this dam has been fully described† by Henry Goldmark, M. Am. Soc. C. E. The dam was to consist of piers, placed 48 ft. from center to center, and be joined by cylindrical arches of concrete, 8 ft. thick at the bottom and 6 ft. thick at the top. The up-stream faces of the piers, and, consequently, of the arches, were to be inclined down stream. A roadway 16 ft. wide was to be constructed on top of the piers, and be supported on arches built between the piers. In order to insure water-tightness, the up-stream face of the dam was to be covered with ¼-in. steel plates. According to the bids received,

* *Engineering News*, September 8th, 1898.

† *Transactions*, Am. Soc. C. E., vol. xxxviii, p. 298.

Mr. Wegmann. this form of dam was found to be from 12 to 15% cheaper than an ordinary dam of uniform section. The Ogden Dam has not yet been built.

About a year ago, the speaker was engaged to design a dam 160 ft. high, which was to consist of piers joined by vertical arches. He found that he could not improve much on the design for the Ogden dam, as far as it went, viz., for a height of 100 ft., and had only to make calculations for an additional 60 ft. in height.

A French engineer has proposed to build a dam as a straight wall, having a comparatively weak section, and to reinforce it by buttresses placed at regular intervals. Some economy in construction might possibly be effected in this manner. The speaker does not know of any dam which has been originally built according to this plan, but the Gros Bois Dam, built in France in 1830 to 1838, was reinforced in 1842 by the construction of nine counterforts, as it deflected several centimeters when subjected to the full water pressure. This dam had a length of 1 805 ft. and a maximum height of 93 ft.

The new type of dam proposed by Mr. Dillman differs from the arched dams mentioned only in substituting between the piers parabolic arches for the ordinary cylindrical arches. The formulas which Mr. Dillman has evolved for his type of dam are exceedingly simple, but Mr. Dillman's type is not the most economical of its class. Applying his type to the proposed Ogden dam, which was to be 100 ft. high and to have the piers 48 ft. from center to center, and comparing it with the design made for the Ogden dam, and, also, with a dam having a uniform cross-section, the result is as follows:

Ogden project....................	86	cu. yds.	per	linear	foot.
Dillman's plan....................	115	"	"	"	"
Uniform dam....................	123	"	"	"	"

This shows that, as far as strength is concerned, a considerable saving in masonry could doubtless be effected by building a dam of piers and arches.

There is, however, another consideration besides stability, *viz.*, the prevention of leakage. In the case of a high dam, even when its base is 100 ft. or more in thickness, some sweating or leakage will generally occur. How, then, could the thin face of masonry proposed by the author, which was to have only the thickness of one-tenth the height, be made water-tight? Ordinary masonry would not suffice for this purpose. Steel plates or asphalt might be used, but would add to the expense of the construction.

While steel plates would make a tight face, there would be some difficulty in connecting them at the bottom and sides of the valley so

that water could not pass around the steel facing. The speaker had thought of using a facing of asphalt for a dam 160 ft. high, which was to consist of piers and arches. The trouble with asphalt, however, is that it is plastic. It could not be used for a vertical face. Experts in asphalt had advised the speaker to give the dam a big slope up stream (which was contrary to the usual design), and to imbed the asphalt between two layers of masonry. The objection to introducing in a dam asphalt or steel plates a certain distance from the up-stream face is that it breaks the continuity of the masonry and makes the calculations of the distribution of the pressure very uncertain. Mr. Wegmann.

The author used the ordinary formulas for the distribution of pressure, which assume it to be either uniform or to vary uniformly, according to the position of the line of pressure. As the width of the piers of the proposed new type diminished toward the down-stream face, the author assumed the pressures to increase from what they would be for an ordinary uniform dam, in proportion as the width of the piers diminished. The formulas applied for calculating the distribution of pressure in an ordinary masonry dam are based on the assumption that the dam is perfectly rigid. While this assumption, of course, is far from being exact, it exaggerates, in all probability, the pressures near the faces of the dam where the masonry is weakest, and, therefore, errs in the direction of safety. When these formulas, however, are applied to piers like those proposed by the author, subjected not only to the water pressure and their own weight, but, also, to arch strains, and having bases that diminish in width down stream, there is a great deal of uncertainty as to the results obtained. The more eccentric the lines of pressure, the less likelihood of the usual formulas for calculating the maximum pressure being applicable to the case.

The author states that he did not see the necessity of limiting the lines of pressure to the center third of the profile, a restriction usually made in the designs of dams since Professor Rankine drew attention to this matter in his valuable report* on "The Design and Construction of Masonry Dams."

According to the laws of a uniformly varying stress, upon which the formulas for the distribution of pressure in a dam are based, tension would occur in the face further from the line of pressure, whenever the latter fell outside of the center third of the profile. While it may seem a little difficult to understand how tension could occur in a wall of masonry, it is likely to take place in the case of an eccentric line of pressure, which would tend to tilt the dam, causing great pressure near one face and a tendency to open at the other.

As regards the question of practical construction, Mr. Dillman's type of dam would be rather troublesome to execute, especially if the

* *The Engineer*, January 5th, 1872.

Mr. Wegmann. down-stream face were to be made of cut stone, as the parabolas forming this face are continually changing according to the height of the dam. Cylindrical arches would be more easily built.

Mr. Dillman has stated that no more intricate mathematics would be involved if the up-stream face of his new type of dam were battered instead of vertical. That might be the case if the weight of water resting on the up-stream face were not considered in the calculations. This omission might be safely made if the up-stream face were steep, as the error involved would be trifling, and in the direction of safety. If the up-stream face, however, had considerable batter, and was similar, for instance, to that assumed for the design for the Ogden Dam, the weight of the water resting on this face, and its moment, have to be included in the calculations, and, doubtless, would make the formulas for determining the cross-section of the dam more complicated.

If some good method were discovered for making a thin wall of masonry practically water-tight under considerable pressure, dams consisting of piers joined by vertical arches would be likely to be constructed in the future, with a view of saving expense. In our present state of knowledge, however, the design of such structures would have to be based upon the results obtained by actual construction, low dams being built at first, and others of greater height when the lower dams had stood successfully for some years.

Mr. Fuller. WILLIAM B. FULLER, M. Am. Soc. C. E.—A dam of the design proposed by the author is worthy of careful study, and such study would lead to a better realization of the essential factors which enter into the construction of dams. There are one or two details of this design which seem very favorable. The leakage through the dam could be under inspection, and controlled so that exactly what was occurring at any time would be known. If there is only a very thin sheet in front, and that can always be inspected, it would be known whether there was anything going on which required repairing or taking care of, and it would seem that this is a matter which ought to be known about any dam, rather than to know hardly anything about it, as in the so-called gravity type.

There should not be any more difficulty in making a dam tight with masonry a few feet thick, say 10 ft., under 100 ft. head, as proposed by the author, than there would be in making it tight if the masonry were 40 to 80 ft. thick; in fact, it would probably be easier to make the thin wall tight than the thick one.

The speaker's experience has been that, where there is a thin sheet of masonry, a great deal more attention can be paid to the detail of its construction, and a great deal richer proportion of cement used with the concrete or masonry without incurring prohibitive costs of construction. In this way it would be possible to get a very much higher

standard of construction than is ordinarily obtained when a large, thick masonry dam is built. Mr. Fuller.

The speaker is of the opinion that there will not be very much difference in the cost of construction in either case; that is, the cost would be put into masonry of a better quality.

The discussion has apparently turned on the fact that such a dam would be of cut-stone masonry, and therefore very expensive to construct, owing to the large amount of face work. In these days it is hardly probable that any such dam would be built; it would probably be built of concrete, which seems to be the favorable construction material at present, and it would not cost much more per unit to make a thin section of such material than a very heavy one.

About three years ago the speaker had occasion to design a dam to hold about 43 ft. of water, and made three different designs. One was a gravity section, of concrete; another was a section somewhat similar to that proposed by the author, with the exception that it had two faces and the interior was hollow, the idea being that a man could pass through the interior of the dam and inspect it at all times, and any seepage through the material would be instantly located. In order to get stability for such a design, it was necessary either to make a very wide base or put in iron, and in this design iron was used to take up the additional stresses instead of using a wide base. Another design considered the dam merely as an iron cantilever truss, entirely surrounded with concrete, and with an apron of concrete in front held up by this truss, thus being very similar in design to that proposed by the author. Bids were received on all three of these designs, and the gravity section was very much the cheapest of the three, and therefore was adopted and built.

MEMOIRS OF DECEASED MEMBERS.

NOTE.—Memoirs will be reproduced in the Volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Secretary prior to the final publication.

THOMAS LAIDLAW RAYMOND, M. Am. Soc. C. E.*

DIED NOVEMBER 15TH, 1901.

Thomas Laidlaw Raymond was born in New Orleans, Louisiana, on May 22d, 1853, and received his preliminary education in the schools of that city. In 1870 he entered the University of Virginia, from which he was graduated in 1874, with the degrees of Civil and Mechanical Engineer and Bachelor of Science.

From January until October, 1875, he was a draftsman in the office of the City Surveyor of New Orleans. From October, 1875, until July, 1876, he taught mathematics in the Preot School, after which he became bookkeeper and cashier for the firm of Elkin and Company.

In May, 1879, Mr. Raymond entered the service of the Government, as U. S. Assistant Engineer, and, during the succeeding nine years, was stationed, successively, at South Pass, Sabine and Blue Buck Passes, Sanibel Island, Bayou Lafourche, Bayou Courtablau, and other points on the Gulf Coast.

From August, 1888, until December, 1896, he was connected with the Board of State Engineers of Louisiana, as Chief Draftsman. In December, 1896, he was chosen as Principal Assistant Engineer of the Drainage Commission of New Orleans, which position he filled until his death.

At the request of the Sewerage and Water Board of New Orleans, Mr. Raymond served as a member of their Advisory Council of Engineers. His interest in this work and in the public welfare was so great that, in view of a legal doubt concerning his right to payment, these services were rendered gratuitously. The duties of these several positions were discharged with an ability and fidelity which won for him the esteem of his employers and associates.

Mr. Raymond's success as an engineer was due partly to special fitness for such work, partly to close observation and application, and largely to a high standard of personal and professional duty. Combined with this equipment he had a good heart and a generous manner, which secured the warm regard of all who had the privilege

* Memoir prepared by the Secretary from papers on file at the House of the Society, and from a Memoir prepared by a Committee of the Louisiana Engineering Society and published in the *Journal* of the Association of Engineering Societies, Vol. xxviii, page 98.

of serving with him. His associates will all join in a recognition of his ability as an engineer and his value as a citizen and friend.

He was married in 1889, and leaves a widow, a son and two daughters. He was active in organizing the Louisiana Engineering Society, and served as its second President, in 1897. His interest in that society continued until his death.

Mr. Raymond was elected a Member of the American Society of Civil Engineers on October 6th, 1897.

CHRISTOPHER CHAMPLIN WAITE, M. Am. Soc. C. E.*

Died February 21st, 1896.

Christopher Champlin Waite was born at Maumee City, Lucas County, Ohio, on September 24th, 1843. He was a son of Morrison Remick Waite, late Chief Justice of the Supreme Court of the United States, and Amelia (Champlin) Waite. He inherited a sturdy strength of character which served him well in a long period of private and public usefulness.

He entered the Rensselaer Polytechnic Institute in 1860, and was graduated in 1864. His first engineering employment was on the Coxsackie Railroad, in 1865 and 1866. During the next two years he was engaged on the Croton Aqueduct for New York City. In 1868 he became Chief Engineer of the Columbus and Toledo Railroad, and Chief Engineer and Superintendent of the Cincinnati and Muskingum Valley Railroad. In 1889 he became President of the Columbus, Hocking Valley and Toledo Railroad, and, under his administration, in spite of strikes and financial embarrassments from other sources, a property which had met with many reverses was converted into a paying investment. He was thoroughly conversant with all the details of the operation of the road, and, while he exacted obedience to a rigid discipline, there was a bond of fellowship between the president and the subordinate.

Mr. Waite was married to Lillie C. Guthrie, daughter of Julius C. Guthrie, of Zanesville, Ohio, on October 22d, 1868, and is survived by his widow and two children, Harry and Ellison.

Mr. Waite was interested in the public affairs of the communities in which he lived, and was at one time Vice-President of the Cincinnati Chamber of Commerce.

He was prominent in charitable work, served as a Trustee of the Children's Hospital, and as President of the Board of Trustees of the

* Memoir prepared by the Secretary from information furnished by H. S. Waite, Esq., and from papers on file.

Ohio State Epileptic Hospital, at Gallipolis, in the organization and management of which he was deeply interested.

He was a lover of art, and had at his home, in Cincinnati, a fine collection of statuary and paintings.

Mr. Waite was elected a Member of the American Society of Civil Engineers on March 3d, 1880.

REGINALD McKEAN, Assoc. M. Am. Soc. C. E.*

DIED OCTOBER 15TH, 1901.

Reginald McKean was of Irish parentage, and was born in Liverpool, England, on September 2d, 1867. He came to the United States in 1871.

He was educated in the public schools of St. Louis, Missouri, supplementing his training there by various courses with specialists in mathematics, chemistry, etc., from time to time, as circumstances permitted.

After a few years spent in office work, failing health admonished him that a more active life was a necessity, and, in 1884, he secured a minor position with the Mississippi River Commission, engaged in dredging near St. Louis. A short time afterward he secured employment in the engineering department of the St. Louis and San Francisco Railroad Company. From that time until the fall of 1896 he was engaged constantly in railroad work, occupying various positions of increasing responsibility, and gained a wide experience in both maintenance and construction work, his field of labor being principally in Missouri, Arkansas and Indian Territory, and with the St. Louis and San Francisco and the Missouri Pacific Companies.

He left the United States in December, 1896, and spent four years in the Transvaal, South Africa, where he was in the employ of the French Rand Gold Mining Company, Limited, as Assistant to the Chief Engineer, having charge of the construction of new work. He was held in highest esteem by the management of this property, and, when war came on, and the officials, who were mostly Englishmen, were compelled to leave the country, he was left in entire charge of the property, a position of great responsibility, anxiety and annoyance, and requiring much patience and tact. In the latter part of 1900 it became possible for a limited number of the officials to return to the mines in the Transvaal, and Mr. McKean was granted a much-needed leave of absence, until such time as it was possible for the mines to resume operations. He left there on December 1st, 1900, and arrived at his home in Cincinnati, Ohio, at Christmas.

* Memoir prepared by J. F. Hinckley, M. Am. Soc. C. E.

Shortly after his return to the United States, there being no prospect of an early termination of the war in South Africa, he accepted a position as Office Engineer in the Construction Department of the St. Louis and San Francisco Railroad Company, with headquarters at Sherman, Texas.

On June 26th, 1901, Mr. McKean was married to Miss Mary Cecilia Denis, of Bond Hill, Ohio, and they at once took up their residence in Sherman.

He died on October 15th, 1901, as a result of an attack of appendicitis.

A distinguishing feature of all Mr. McKean's work was a conscientious thoroughness and absolute fidelity to the best interests of his employers. In his social life, he was a most agreeable companion, kindly considerate of others, and of unruffled serenity under all conditions.

Mr. McKean was elected an Associate Member of the American Society of Civil Engineers on May 2d, 1894.

PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

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(INSTITUTED 1852.)

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House of the Society—220 West Fifty-seventh Street, New York.

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Cable Address, - - - - - "Ceas, New York."

Vol. XXVIII. SEPTEMBER, 1902. No. 7.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PROCEEDINGS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

SOCIETY AFFAIRS.

CONTENTS:

MINUTES OF MEETINGS.

OF THE SOCIETY.

September 3d, 1902.—The meeting was called to order at 8.35 P. M., Rudolph Hering, M. Am. Soc. C. E., in the chair; Assistant Secretary T. J. McMinn acting as Secretary; and present, also, 59 members and 8 visitors.

The minutes of the meetings of the Annual Convention, held at Washington, D. C., May 20th to 23d, and of June 4th, 1902, were approved as printed in *Proceedings* for August, 1902.

A paper by R. C. McCalla, M. Am. Soc. C. E., entitled "Improvement of the Black Warrior, Warrior and Tombigbee Rivers, in Alabama," was presented in abstract by the Acting Secretary, who also read discussions by Messrs. W. L. Sibert, George Y. Wisner and D. A. Watt. Additional communications on the subject, by Messrs. John M. G. Watt and Nat. A. Yuille were presented by title only. The paper was discussed orally by Messrs. Edward P. North and Samuel Whinery.

Ballots for membership were canvassed, and the following candidates were elected.

As Members.

Walter Eugene Angier, Thebes, Ill.
Frederick Thomas Barcroft, Detroit, Mich.
Oliver W Childs, St. Louis, Mo.
Frederick William Cohen, Harrisburg, Pa.
Stephen Elbridge Coombs, Cape Girardeau, Mo.
William Williams Crehore, New York City.
Griffith Morgan Eldridge, Tampa, Fla.
Elliot Holbrook, Kansas City, Mo.
Edward Ten Eyck Lansing, Little Falls, N. Y.
William Naylor McDonald, Havana, Cuba.

As Associate Members.

Richard I Downing Ashbridge, Philadelphia, Pa.
Miles Carlisle Bland, Cleveland, Ohio.
Abraham Gideon, Havana, Cuba.
John Thomas Henderson, Hartford, Conn.
Francis Dey Hughes, Kansas City, Mo.
George Albert Noska, New York City.
Henry Van Buren Osbourn, Philadelphia, Pa.
John Gates Peck, Albany, N. Y.
Eugene Everett Pettee, Newtonville, Mass.
James Walter Rickey, Minneapolis, Minn.
Louis John Riegler, Allegheny, Pa.
George Thomas Roberts, Buffalo, N. Y..
Francis Nicoll Sanders, Albany, N. Y.
Moses Hannibal Wright, Nashville, Tenn.

The Acting Secretary announced that at the meeting of the Board of Direction, September 2d, 1902, reconsideration ballots had been canvassed, and that the following candidates had been elected:

As Members.

Otto Marc Eidlitz, New York City.
Hans August Evald Conrad von Schon, Sault Ste. Marie, Mich.

As Associate Member.

George Corrie Bartram, Boston, Mass.

The Acting Secretary announced that at the meeting of the Board of Direction, September 2d, 1902, the following candidates had been elected:

As Juniors.

Frank Lorn Campbell Bond, New York City.
Harry Gilbert Burrowes, Brooklyn, N. Y.
William Stewart Getchell, Denver, Colo.
Robert Austen McCulloch, Orange, N. J.
Rudolph Quanz, West Hoboken, N. J.
Clinton Leroy Richardson, New York City.
Albert Lyman True, Portland, Me.

The Acting Secretary announced the following deaths:

Oscar F. Whitford; elected Member December 6th, 1871; died May 21st, 1902.

Arthur Stanley Hobby; elected Member June 6th, 1894; died May 28th, 1902.

Peter Milne; elected Associate January 7th, 1896; died June 9th, 1902.

Milton Grosvenor Howe; elected Member October 16th, 1872; died June 19th, 1902.

John Butler Johnson; elected Member April 7th, 1886; died June 23d, 1902.

Ira Alexander Shaler; elected Junior July 4th, 1888; Member June 5th, 1895; died June 29th, 1902.

Lorenzo Russell Clapp; elected Member February 1st, 1888; died August 13th, 1902.

William Hasell Wilson; elected Honorary Member August 2d, 1892; died August 17th, 1902.

Edmund Phillips Hannaford; elected Member September 18th, 1872; died August 19th, 1902.

Adjourned.

September 17th, 1902.—The meeting was called to order at 8.40 P. M., J. A. Ockerson, M. Am. Soc. C. E., in the chair; T. J. McMinn, Assistant Secretary, acting as Secretary; and present, also, 97 members and 12 guests.

A paper entitled "The Maintenance of Asphalt Streets," by James N. Hazlehurst, M. Am. Soc. C. E., was presented by the Acting Secretary.

The subject was discussed by Messrs. Samuel Whinery, N. P. Lewis, W. Boardman Reed, A. V. Abbott, J. M. Evans and S. C. Thompson.

The Acting Secretary announced the death of the following members:

William Durfee Gelette, elected Member April 1st, 1885; died April 27th, 1902.

Henry Lawrence Cleverdon, elected Associate Member March 1st, 1899; died August 27th, 1902.

Adjourned.

ANNOUNCEMENTS.

The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

MEETINGS.

Wednesday, October 1st, 1902.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and a paper by Theron A. Noble, M. Am. Soc. C. E., entitled "The Flow of Water in Wood Pipes," will be presented for discussion.

This paper was printed in the *Proceedings* for August, 1902.

Wednesday, October 15th, 1902.—8.30 P. M.—At this meeting, a paper, entitled "The Protection and Improvement of Foreshores by the Utilization of Tidal and Wave Action," by R. G. Allanson-Winn, M. Inst. C. E., I., will be presented for discussion.

This paper was printed in the *Proceedings* for August, 1902.

Wednesday, November 5th, 1902.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and a paper by Isaac Harby, Jun. Am. Soc. C. E., entitled "The Foot-bridge for Building the Cables of The New East River Bridge," will be presented for discussion.

This paper is printed in this number of *Proceedings*.

ACCESSIONS TO THE LIBRARY.

From August 6th to September 9th, 1902.

DONATIONS.*

MATERIALS OF MACHINES.

By Albert W. Smith. Cloth, 7½ x 5 ins., 142 pp., illus. New York, John Wiley & Sons, 1902. $1.00.

In the prefatory note, the author states that this book is the result of an effort to bring together concisely the information necessary to him who has to select materials for machine parts. The chapter headings are: Outline of the Metallurgy of Iron and Steel; Testing; Stress-Strain Diagrams; Cast Iron; Wrought Iron and Steel; Alloys; Selection of Material. There is an index of seven pages.

TABLES FOR CALCULATING THE CUBIC CONTENTS OF EXCAVATIONS AND EMBANKMENTS.

By John R. Hudson, M. Am. Soc. C. E. Third Edition. Cloth, 9 x 6 ins., 131 pp. New York, John Wiley & Sons, 1902. $1.00.

The preface calls attention to a short and simple rule, which, in three-level ground, is well adapted to take the place of the ordinary method of "averaging end areas," and giving the same answer, while the process is one-third shorter. An example, given in the preface, shows that the entire process consists in addition, subtraction, and inspection of the tables, thus avoiding the errors likely to occur in the multiplications forming part of the usual methods. When three heights are taken at a station, the examples in the preface show, by comparison, the advantage of using the methods of computing earthwork quantities given in this work. Forms for cross-section books are shown, which will be found useful and convenient for recording and preserving field notes and office computations when these tables are used.

Gifts have also been received from the following:

Aachen Königliche Technische Hochschule. 3 pam.
Alabama Great Southern R. R. Co. 1 pam.
Am. Inst. of Elec. Engrs. 1 bound vol.
Am. Water-Works Assoc. 1 vol.
Belgium—Officiers du Génie de l' Armée Belge. 1 pam.
Berlin Königliche Technische Hochschule. 1 pam.
Boston—Dept. of Parks. 1 pam.
Buffalo, Rochester & Pittsburg Ry. Co. 1 pam.
Canadian Min. Inst. 1 vol.
Central of Georgia Ry. Co. 1 pam.
Chicago & Eastern Illinois R. R. Co. 1 pam.
Chicago & North Western Ry. Co. 1 pam.
Delaware & Hudson Co. 1 bound vol., 3 pam.
Eckel, Edwin C. 1 pam.
Eng. Assoc. of New South Wales. 1 bound vol.
Engrs. Club of Philadelphia. 1 bound vol.
Engrs. Club of St. Louis. 1 bound vol.
Geographical Soc. of Philadelphia. 1 pam.
Gila Valley, Globe & Northern Ry. Co. 1 pam.
Great Britain—Patent Office. 2 vol., 5 pam.
Greenhalge, F. T. 2 bound vol.
Hannover Königliche Technische Hochschule. 1 pam.
Humphrey, Richard L. 1 vol.
India—Director of Railway Construction. 1 bound vol., 18 pam.
India—Pub. Works Dept. 1 bound vol.
Inst. of Civ. Engrs. 2 bound vol.
Iron and Steel Inst. 1 bound vol.
Kummer, F. A. 1 pam.
Mass.—Highway Comm. 7 bound vol.
Midland Ry. Co. 1 pam.
Mining Inst. of Scotland. 1 vol.
Municipal Engineering. 7 vol.
N. Y. Pub. Lib. 360 bound vol., 194 vol., 220 pam.
Parsons, Arthur L. 1 pam.
Quick, A. M. 1 bound vol.
Reissner, H. 2 pam.
R. I.—Commr. of Dams and Reservoirs. 18 pam.
St. John, N. B.—Water and Sewerage Board. 1 pam.
Smithsonian Inst. 1 bound vol.
Soc. Belge des Ingénieurs et des Industriels. 1 pam.
Switzerland—Bureau Hydrométrique Fédéral. 1 vol.
Tenn. Univ. 6 bound vol.
Toledo, Ohio—Water-Works. 1 pam.
U. S. Corps of Engrs. 42 specif.
U. S. Geological Surv. 3 bound vol., 1 vol., 8 pam.
U. S. Weather Bureau. 3 bound vol., 2 pam.
Univ. of Ill. Agricultural Exper. Station. 4 pam.
Whipple, George C. 1 pam.
Wis. Free Lib. Comm. 1 vol.

* Unless otherwise specified, books in this list have been donated to the Library by the Publisher.

BY PURCHASE.

Report on Prussian Railways. By Robert Collier. Presented to both Houses of Parliament by command of His Majesty, February, 1902. London, 1902.

SUMMARY OF ACCESSIONS.

From August 6th to September 9th, 1902.

Donations (including 92 duplicates)	934
By purchase	1
Total	935

MEMBERSHIP.

ADDITIONS.

MEMBERS.

		Date of Membership.
ANGIER, WALTER EUGENE		
Res. Engr., S. Ill. & Mo. Bridge Co., Thebes, Ill.	Assoc. M.	Sept. 7, 1892
	M.	Sept. 3, 1902
BARCROFT, FREDERICK THOMAS		
407 Ferguson Bldg., Detroit, Mich.		Sept. 3, 1902
CHILDS, OLIVER W		
Chf. Engr., Stupp Bros. Bridge & Iron Co., 2301 South 7th St., St. Louis, Mo.	Assoc. M.	Sept. 5, 1900
	M.	Sept. 3, 1902
COOMBS, STEPHEN ELBRIDGE		
510 Granite Blk., St. Louis, Mo.		Sept. 3, 1902
CREHORE, WILLIAM WILLIAMS	Assoc. M.	April 4, 1894
39 Cortlandt St., New York City.	M.	Sept. 3, 1902
EIDLITZ, OTTO MARC		
489 Fifth Ave., New York City.		Sept. 2, 1902
LANSING, EDWARD TEN EYCK		
City Engr., Little Falls, N. Y.		Sept. 3, 1902
VON SCHON, HANS AUGUST EVALD CONRAD		
Chf. Engr., Michigan Lake Superior Power Co., Sault Ste. Marie, Mich.		Sept. 2, 1902

ASSOCIATE MEMBERS.

BARTRAM, GEORGE CORRIE		
Res. Engr., Phœnix Bridge Co., 153 Milk St., Boston, Mass.	Jun.	Jan. 31, 1899
	Assoc. M.	Sept. 2, 1902
BLAND, MILES CARLISLE		
Contr. Mgr., American Bridge Co. of New York, 418 Chamber of Commerce Bldg., Cleveland, Ohio.		Sept. 3, 1902
FAIN, JAMES RHEA		
Sub.-Insp., U. S. Navy Yard, League Island (Res., 2132 South Broad St., Philadelphia), Pa.		June 4, 1902
GUERINGER, LOUIS AMEDEE		
Asst. Engr., I. & G. N. R. R., Italy, Tex.		May 7, 1902
HUGHES, FRANCIS DEY		
Asst. Engr., Midland Bridge Co., Box 385, Kansas City, (Res., 220 South Liberty St., Independence), Mo.		Sept. 3, 1902
HYDE, WILLIAM HERBERT	Jun.	April 30, 1901
Ravenna, Ohio.	Assoc. M.	June 4, 1902
NOSKA, GEORGE ALBERT	Jun.	Mar. 31, 1896
33 East 17th St., New York City.	Assoc. M.	Sept. 3, 1902
OSBOURN, HENRY VAN BUREN		
Ye Golden Swan, Mount Airy, Philadelphia, Pa.		Sept. 3, 1902

	Date of Membership.
PECK, JOHN GATES	
483 Hamilton St., Albany, N. Y.	Sept. 3, 1902
PITTS, THOMAS DORSEY	
Chf. Draftsman, Tams, Lemoine & Crane, Naval Archts., 52 Pine St., New York City. — Jun.	Dec. 7, 1897
— Assoc. M.	June 4, 1902
RIEGLER, LOUIS JOHN	
417 Third St., Allegheny, Pa.	Sept. 3, 1902
THOMPSON, ARTHUR WEBSTER	
Div. Engr., Pittsburg Div., B. & O. R. R., Cumberland, Md.	June 4, 1902

ASSOCIATE.

GAINES, FRANKLIN LINCOLN	
Vice-Pres. and Gen. Supt. of Constr., Grand Rapids Bridge Co., 612 Pythian Temple, Grand Rapids, Mich.	April 1, 1902

JUNIORS.

BARNES, WALTER ESMOND	
45 Lincoln St.. Malden, Mass.	May 6, 1902
McCULLOCH, ROBERT AUSTEN	
80 Hillside Ave., Orange, N. J.	Sept. 2, 1902
MILLER, STANLEY ALFRED	
With Nicol & Co., Pollock Bldg., Mobile, Ala.	Feb. 4, 1902
WACHTER, CHARLES LUCAS	
96 Liberty St., New York City	June 3, 1902
WARNER, GEORGE LITTLETON	
2926 Fifteenth St., N. W., Washington, D. C.	April 1, 1902

CHANGES OF ADDRESS.

MEMBERS.

ABBOTT, ARTHUR VAUGHAN	8 Bridge St., New York City.
BEARDSLEY, JAMES WALLACE	U. S. Asst. Engr., Manila, Philippine Islands.
BOYNTON, GEORGE HERBERT	Asst. Engr., C., R. I. & P. Ry. Co., 610 Grand Central Passenger Station, Chicago, Ill.
BYLLESBY, HENRY MANSON	309 Merchants' Loan and Trust Bldg., Chicago, Ill.
COE, WILLIAM WATSON	Engr., Contr. Work, Branch Lines, N. & W. Ry. Co., Kenova, W. Va.
CUNNINGHAM, ANDREW OSWALD	Bridge Engr., The Wabash R. R. Co., St. Louis, Mo.
DUNHAM, CHARLES FREDERICK	Care, James Owen, Montclair, N. J.
FILLEY, HIEL HAMILTON	Res. Mgr. and Chf. Engr., The Guanajuato Power & Electric Co., Zamora, Michoacan, Mexico.
FRANCIS, GEORGE BLINN	Care, Westinghouse, Church, Kerr & Co., 8 Bridge St., New York City.

GOULD, WILLIAM TILLOTSON........Chf. Engr's Office, Brooklyn Heights R. R. Co., Franklin Trust Bldg., Brooklyn, N. Y.
HANSEL, CHARLES..................Broad Exchange Bldg., New York City.
HAZARD, SCHUYLER.................Res. Engr., Catawba Power Co., Rock Hill, S. C.
JENKINS, WILLIAM DUNBAR.........Locating Engr., Bessemer & Lake Erie R. R. Co., Chicora, Butler Co., Pa.
KIMBALL, GEORGE HENRY...........Chf. Engr., Pere Marquette R. R. Co., 72 Delaware Ave., Detroit, Mich.
LINVILLE, JACOB HAYS..............Lansdowne, Pa.
MARDEN, HENRY HERMAN, Jr........515 Bedford Ave., Brooklyn, N. Y.
MILLER, HARVEY COOPER...........68 Beaver St., New York City.
MILLS, CHARLES MALON.............Prin. Asst. Engr., Subway & Elevated R. R. Constr., Philadelphia Rapid Transit Co. (Res., 4813 Beaumont St.), Philadelphia, Pa.
MOSSCROP, ALFRED MITTON.........Vice Pres. and Engr.. Structural Iron & Steel Co., Baltimore, Md.
PAGET, EDMUND WINTER............(Paget & Clark, Civ. Engrs. and Surveyors), Room 38, Washington Bldg., Portland, Ore.
SCHENCK, ARCHIBALD ALEXANDER....Chf. Engr., Fremont, Elkhorn & Missouri Valley R. R. Co., Omaha, Neb.
SCHERMERHORN, LOUIS YOUNGLOVE .Pres., American Dredging Co., 510 Mariner and Merchant Bldg., Philadelphia, Pa.
SMITH, HENRY DEWITT............ Res. Engr., Louisiana & Arkansas R. R. Co., Hope, Ark.
SNYDER, GEORGE DUNCAN.......... Care, C. M. Jacobs, 20 West 34th St., New York City.
THOMAS, BENJAMIN FRANKLIN.......Louisa, Ky.
WEBSTER, CHARLES EDWARD. ....Cons. Engr., South Bethlehem, Pa.

ASSOCIATE MEMBERS.

FISH, JOHN CHARLES LOUNSBURY.....Box 20, Palo Alto, Cal.
FOX, WALTER GORDON............. Batesville, Ark.
FRAZEE, JOHN HATFIELD ....516 West 133d St., New York City.
GREENE, FREDERICK STUART........336 West 95th St., New York City.
HARRINGTON, FERDINAND FINNEY... Bridge Dept., N. Y. C. & H. R. R. R. Co., Grand Central Station, New York City.
HARTE, CHARLES RUFUS............34 Elm St., Jamaica Plain, Mass.
HARTWELL, HARRY.... ....53 East 87th St., New York City.
HOUSTON, GAVIN NELSON............University Park, Denver, Colo.
HUESTIS, CHARLES CALVIN........ ..Gen. Mgr., The T. H. Riddle Constr. Co., North Mountain, W. Va.
LAVIS, FRED........................Asst. Engr., N. Y., N. H. & H. R. R., Fall River, Mass.
MARTIN, JAMES WILLIAM.......... 323 Quincy St., Pueblo, Colo.

MOREY, RICHARD....................Gen. Mgr., Morey Engineering & Constr. Co., 807 Carleton Bldg., St. Louis, Mo.

PFEIFER, HERMAN JULIUS...........509 Commonwealth Trust Bldg., St. Louis, Mo.

PHARR, HARRY NELSON............ Chf. Engr., St. Francis Levee Board, Randolph Bldg., Memphis, Tenn.

REID, HOMER AUSTIN...............Asst. Engr., Rapid Transit R. R. Comm. (Res., 177 Columbia Heights), Brooklyn, N. Y.

SWAAB, SOLOMON MARK.............Asst. Engr., Philadelphia Rapid Transit Co., Philadelphia, Pa.

WHEATLEY, ARTHUR CORNWALLIS....Res. Director and Gen. Mgr., The Trinidad Mining & Smelting Co., 2017 San Pedro Ave., San Antonio, Texas.

WILLS, ARTHUR JOHN...............Salisbury, N. C.

ASSOCIATE.

ECKEL, EDWIN CLARENCE.......... Asst. Geologist, U. S. Geological Survey, Washington, D. C.

JUNIORS.

BEACH, JAMES GEORGE .... Care, Geo. A. Fuller Co., North American Bldg., Philadelphia, Pa.

BISSELL, CLINTON TALCOTT..........7 St. James Pl, Brooklyn, N. Y.

FORBES, HENRY DE BRETTON ....Engr., H. E. Talbott & Co., Dayton, Ohio.

HORTON SANDFORD..................316 Virginia Ave., Room 9, Indianapolis, Ind.

MORPHY, LUIS GONZAGA.............Asst. Engr., N.Y. C. & H. R. R. R., Room 14, Albany Station, Albany, N. Y.

NEVILLE, COLONE WILL JACKSON.....Engr., American Bridge Co., 6032 Kimbark Ave., Chicago, Ill.

UNDERWOOD, HOWARD WARREN.....232 Eagle St., North Adams, Mass.

WHITE, FRANK GEORGE.............32 Third East St., Salt Lake City, Utah.

DEATHS.

CLAPP, LORENZO RUSSELL...........Elected Member February 1st, 1888; died August 13th, 1902.

HANNAFORD, EDMUND PHILLIPS......Elected Member September 18th, 1872; died August 19th, 1902.

WILSON, WILLIAM HASELL... ......Elected Honorary Member August 2d, 1892; died August 17th, 1902.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST.

(August 6th to September 9th, 1902.)

NOTE.—*This list is published for the purpose of placing before the members of the Society the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS.

In the subjoined list of articles references are given by the number prefixed to each journal in this list.

(1) *Journal*, Assoc. Eng. Soc., 257 South Fourth St., Philadelphia, Pa., 30c.
(2) *Proceedings*, Eng. Club of Phila., 1122 Girard St., Philadelphia, Pa.
(3) *Journal*, Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal*, Western Soc. of Eng., Monadnock Block, Chicago, Ill.
(5) *Transactions*, Can. Soc. C. E., Montreal, Que., Can.
(6) *School of Mines Quarterly*, Columbia Univ., New York City, 50c.
(7) *Technology Quarterly*, Mass. Inst. Tech., Boston, Mass., 75c.
(8) *Stevens Institute Indicator*, Stevens Inst., Hoboken, N. J., 50c.
(9) *Engineering Magazine*, New York City, 25c.
(10) *Cassier's Magazine*, New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 35c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News*, New York City, 15c.
(14) *The Engineering Record*, New York City, 12c.
(15) *Railroad Gazette*, New York City, 10c.
(16) *Engineering and Mining Journal*, New York City, 15c.
(17) *Street Railway Journal*, New York City, 35c.
(18) *Railway and Engineering Review*, Chicago, Ill., 10c.
(19) *Scientific American Supplement*, New York City, 10c.
(20) *Iron Age*, New York City, 10c.
(21) *Railway Engineer*, London, England, 25c.
(22) *Iron and Coal Trades Review*, London, England, 25c.
(23) *Bulletin*, American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gas Light Journal*, New York City, 10c.
(25) *American Engineer*, New York City, 20c.
(26) *Electrical Review*, London, England.
(27) *Electrical World and Engineer*, New York City, 10c.
(28) *Journal*, New England Water-Works Assoc., Boston, $1.
(29) *Journal*, Society of Arts, London, England, 15c.
(30) *Annales des Travaux Publics de Belgique*, Brussels, Belgium.
(31) *Annales de l' Assoc. des Ing. Sortis des Ecôle Spéciales de Gand*, Brussels, Belgium.
(32) *Mémoires et Compte Rendu des Travaux*, Soc. Ing. Civ. de France, Paris, France.
(33) *Le Génie Civil*, Paris, France.
(34) *Portefeuille Économique des Machines*, Paris, France.
(35) *Nouvelles Annales de la Construction*, Paris, France.
(36) *La Revue Technique*, Paris, France.
(37) *Revue de Mécanique*, Paris, France.
(38) *Revue Générale des Chemins de Fer et des Tramways*, Paris, France.
(39) *Railway Master Mechanic*, Chicago, Ill., 10c.
(40) *Railway Age*, Chicago, Ill., 10c.
(41) *Modern Machinery*, Chicago, Ill., 10c.
(42) *Transactions*, Am. Inst. Elec. Engrs., New York City, 50c.
(43) *Annales des Ponts et Chaussées*, Paris, France.
(44) *Journal*, Military Service Institution, Governor's Island, New York Harbor, 50c.
(45) *Mines and Minerals*, Scranton, Pa., 20c.
(46) *Scientific American*, New York City, 8c
(47) *Mechanical Engineer*, Manchester, England.
(58) *Proceedings*, Eng. Soc. W. Pa., 410 Penn Ave., Pittsburg, Pa., 50c.
(59) *Transactions*, Mining Inst. of Scotland, London and Newcastle-upon-Tyne.
(60) *Municipal Engineering*, Indianapolis, Ind., 25c.
(61) *Proceedings*, Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *American Manufacturer and Iron World*, 59 Ninth St., Pittsburg, Pa.
(63) *Minutes of Proceedings*, Inst. C. E., London, England.
(64) *Power*, New York City, 20c.
(65) *Official Proceedings*, New York Railroad Club, Brooklyn, N. Y., 15c.
(66) *Journal of Gas Lighting*, London, England, 15c.
(67) *Cement and Engineering News*, Chicago, Ill., 25c.

LIST OF ARTICLES.

Bridge.

American Workshop Methods in Steel Construction (Pencoyd Bridge Works).* Henry Bridges Molesworth, M. Inst. C. E. (63) Vol. cxlviii.
Masonry and Steel Arches on the Chicago, Milwaukee & St. Paul.* (40) Aug. 8.
Boulder-Faced Melan Arch Bridge, National Park, Washington, D. C.* W. J. Douglas. (13) Aug. 14.
The Rock Creek Concrete-Steel Arch, Washington.* (14) Aug. 16.
A New Bridge over the Fraser River at New Westminster, British Columbia.* (15) Aug. 29.
Heavy Concrete Arches.* (14) Aug. 30.
Concrete-Steel Bridges.* D. B. Luten. (60) Sept.
The Bascule Bridge at West Division Street, Chicago.* (20) Sept. 4.

Electrical.

The Testing of Combined Steam-Engine and Dynamo Sets.* Edwin Hartree Rayner, Stud. Inst. C. E. (63) Vol. cxlviii.
The Telephonic Status Quo. Arthur Vaughan Abbott. (42) Apr.
Telephone Rates from an Engineer's Viewpoint. Franz J. Dommerque. (42) Apr.
Power Consumption of Elevators Operated by Alternating and Direct Current Motors. George F. Sever. (42) Apr.
Telpherage.* Charles M. Clark. (42) Apr.
The New Generating Plants of the Niagara Falls Power Company.* H. W. Buck. (42) May.
Notes on the Theory of the Synchronous Motor, with Special Reference to the Phenomenon of Surging. Charles Proteus Steinmetz. (42) May.
A Method of Compounding Alternating Current Generators and Motors, Direct Current Generators, Synchronous Motor-Generators and Synchronous Converters.* Frank George Baum. (42) May.
Formula for Calculating the Electromotive Force at any Point of a Transmission Line for Alternating Current. M. Leblanc. (42) May.
An Experiment with Single-Phase Alternators on Polyphase Circuits. C. O. Mailloux. (42) May.
Energy Loss in Commercial Insulating Materials when Subjected to High Potential Stress. Charles Edward Skinner. (42) May.
Report of the Committee on Standardization. American Institute of Electrical Engineers. (42) May.
The Determination of Alternator Characteristics. Louis A. Herdt. (42) May.
A New Curve Tracing Instrument. Robert B. Owens. (42) May.
The Function of Shunt and Series Resistance in Lightning Arresters. Percy H. Thomas. (42) May.
The Electrostatic Wattmeter in Commercial Measurements. Miles Walker. (42) May.
Storage Batteries in Mills and Factories. E. Vail Stebbins. (1) July.
Newcastle and District Electric Lighting Company's Power Station.* W. D. Hunter. (Paper read before the Inst. of Mech. Engrs.) (11) Aug. 1.
Some Suggestions with regard to Electric Motor Installations. Alfred H. Mayes. (26) Aug. 1.
The Electric-Supply Power Station at Neptune Bank, Newcastle-upon-Tyne.* W. B. Woodhouse, Assoc. M. Inst. M. E. (Paper read before the Inst. of Mech. Engrs.) (11) Aug. 1.
The Correct Type of Engine for Large Generating Stations. A. A. Day. (Paper read before the Incorporated Municipal Electrical Assoc.) (47) Aug. 2.
The Old and the New Electrical Theory. Alex. P. Trotter. (26) Serial beginning Aug. 8.
Missouri River Power Company's 50 000-Volt Transmission Plant.* A. W. Clapp. (27) Aug. 9.
Electric Lighting and Power in San Francisco.* (26) Aug. 15.
Direct Measurement of Wattless Power. Budd Frankenfield. (27) Aug. 16.
High-Tension Circuit Safeguards* Joseph Martin Roman. (27) Aug. 16.
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By ISAAC HARBY, JUN. AM. SOC. C. E.

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The erection of one suspension bridge from which to build the cables of another has introduced new ideas and instituted a new procedure in the methods of constructing bridges of this type. The cables of the New East River Bridge No. 2, also designated as "The Williamsburg Bridge," are novel in other respects. They are the largest suspension bridge cables ever attempted, and are suspended from towers taller than those in use in any other bridge. These towers are also distinguished by being the first large ones of steel to be used for this purpose.

It is not unnatural, then, that new methods should characterize the work of building such cables.

The engineer in charge of the contract for constructing these cables, Wilhelm Hildenbrand, M. Am. Soc. C. E., whose assistant the writer is, has invented a method of doing better work of this class in a shorter time than has previously been accomplished on any other similar undertaking.

NOTE.—These papers are issued before the date set for presentation and discussion. Correspondence is invited, from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers with discussion in full will be published in *Transactions*.

FIG. 1.—NEW EAST RIVER BRIDGE NO. 2: TOWERS AND END SPANS READY FOR CABLES.

FIG. 2.—REELS OF WIRE ROPE ON FLOAT BEING TOWED ACROSS RIVER AND LAID ON THE BOTTOM.

Before entering into the main subject of this paper, a more comprehensive idea of the situation may be given by a brief description of the main cables themselves, the erection of which was the reason for the existence of the footbridge. The writer will also state briefly the conditions encountered at the beginning of the undertaking.

There are to be four main cables, each composed of 37 strands of 208, No. 6, steel wires, laid straight; all of which are finally to be squeezed into one cylindrical cable measuring about 19 ins. in diameter.

The distance between the centers of the towers is 1 600 ft. The cables are to be passed over the tops of these, where each one is to rest in a saddle mounted on rollers permitting a motion of 3 ft. in the direction of the cable.

The weight of the main span of the bridge is to be carried directly by the cables, but the parts of the bridge between the towers and the anchorages are to be otherwise supported. Thus the back stays, or shore spans, of the cables will have no load suspended from them. In order to equalize the tensions in the shore spans and the main span of the cables during their construction the saddles are moved back on their roller beds 3 ft. toward the anchorages and held there. This position has been determined by calculation as the proper one to balance the forces caused by the tension in the unloaded cable. The saddles will move forward gradually during the erection of the superstructure of the main span.

The elevation of the center of the cable where it will rest in the saddle is to be 332.708 ft. above mean high water, and the elevation at its lowest point in the main span is to be 161.027 ft. The cables will be anchored 617 ft. (measured horizontally) from the center of each tower, at an elevation of 76.627 ft. The end of each strand will be looped around a cast-steel shoe, held by a pin passed through the end of a chain of eye-bars built in a masonry anchorage.

During the spinning of the wires it will be necessary to support each strand on sheaves a little above the position it will finally occupy in the saddle, and also to hold each end of the strand a little back of its final position in the anchorage. The combined result of this condition will cause the center of the main span of each strand to hang about 14 ft. higher while it is being made than it will after it is lowered into its final position.

Reasons for Constructing a Footbridge.

On previous work of this kind a so-called footbridge was used, but it consisted merely of a single path from anchorage to anchorage, used only as a means of passage, and not intended as a working platform. In the case of the New York and Brooklyn Bridge, this footwalk was suspended on two 2⅝-in. wire ropes. When the Cincinnati and Covington Bridge (the second largest suspension bridge now in use) was recently rebuilt by Mr. Hildenbrand, by the addition of extra cables above the old ones, the footbridge there in use was laid on top of one of the old cables.

The wrapping of the strands and of the finished cable has previously been done from travelers suspended from the cable itself. The regulation or adjustment of the wires has been accomplished by the assistance of cradles, suspended at several points along the line, from which men could reach the wires during regulation.

These methods left much room for improvement, and it became quite evident that if some sort of a working platform could be devised, extending the full length of the cables to be built, and from which the cables could be reached at all points and at all times, a much better cable could be built in a much shorter time.

Thus the demand for such a working platform called into active service the inventive mind of the engineer in charge of the execution of the contract, and he has designed an original as well as an ingenious method of building large cables.

Description of the Footbridge.

This footbridge is more than an ordinary footwalk from tower to tower. In the main or river span it is a double-deck bridge, and consists of eight continuous footways, four above and four below. The four upper footwalks are about 4 ft. below the line which will be occupied by the strands of the main cable during the time of spinning. The four lower walks are just below the line to be occupied by the cable when the strands have been placed in their permanent position.

These different footwalks are connected by cross-bridges at numerous points, so that an easy communication is afforded from all parts of the structure.

The two land spans are placed directly below the line of the cables, and have only a single deck of four walks.

PLATE XXXII.
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CABLES OF SUSPENSION BRIDGE.

Fig. 1.—Saddles for Main Cable and Footbridge Cables, on Tower.

Fig. 2.—Placing Socket on End of Rope.

The whole structure is supported by sixteen wire ropes assembled into four groups of three ropes each, with a single rope suspended above each group. These ropes are stretched from anchorage to anchorage, and passed over the tops of the towers in saddles especially provided for them.

The three ropes composing a cable are clamped together with iron bands every 5 ft., so as to keep the three together throughout their entire length.

These ropes are 2¼ ins. in diameter, and are made of seven strands of galvanized steel wires, twisted together. The ultimate strength of each is 208 tons, and the weight 9 lbs. per foot. Each rope was made long enough to extend the entire distance from anchorage to anchorage, about 3 020 ft.

The ends of these cables were made fast to a 30-in. box-girder spanning an opening in the face of an inner wall of the anchorage, the girder being set at such an inclination that the end of each wire rope could pass through it parallel to its web. The ropes thus passed through are secured by means of button sockets which bear against the back of the girder.

In order to permit of some adjustment in the lengths of the different ropes forming the cables, and also for convenience in erecting, each is pieced, about 100 ft. from each end, and reunited by means of sockets with screw rods passing through them. These rods are 3¼ ins. in diameter, 6½ ft. long, and are threaded at each end. They permit of an adjustment of 4 ft.

The ends of the four ropes are spaced along the anchorage girder about 1 ft. apart, and the ropes converge to a point on the front wall of the anchorage where they pass over a cast-iron saddle. Between this saddle and the saddle on the main tower they are clamped into one cable, and form the support for the land span of the footbridge.

The clamps are spaced every 5 ft., measured horizontally, and from each hangs a suspender rod of ¾-in. round iron and an inclined 1-in. suspender reaching sideways. Between each pair of cables is a ⅝-in. tie-rod. The lower ends of the suspenders pass through 3 x 8-in. yellow pine beams, upon which the 2 x 6-in. flooring is laid. As the slope of the land span becomes steeper as the towers are approached, it was found necessary to break the grade with a step at each beam for about two-thirds of the distance, and the rise of these steps increases with

the elevation. Spruce posts bolted to each beam support a ⅝-in. galvanized wire rope handrail stretched tight. Frame towers at the middle of the land span carry sheaves for supporting a traveling rope at that point.

The main span, 1 600 ft. in length, is supported for a distance of 400 ft. out from each tower by means of 1-in. suspender rods; and the remaining 800 ft., at the center of the span; rests directly on top of the cables, and is clamped to them by means of U-bolts passing between two 3 x 8-in. yellow pine floor beams bolted together. The suspender rods are hung to the clamps which bind the three ropes together. The lower ends of the suspenders are passed between the two floor beams at each point. The suspenders decrease in length as the distance from the tower increases, until they are discontinued, about 400 ft. out, where the beams rest directly on top of the cables, and are secured with U-bolts. Planking, 2 x 6-in., with 2-in. spaces between, laid across the floor beams, forms a footwalk. Cleats nailed cross-ways add to the security of the foothold.

The upper deck of the main span is supported on posts which rest directly upon the beams of the lower deck. These posts are capped with stringers which in turn carry beams to which is nailed the flooring similar to that on the lower deck. Handrails of ⅝-in. galvanized wire ropes are stretched on both sides of each walk.

The bridge is stiffened laterally by a cross-bracing of ⅝-in. rods.

Four 2¼-in. storm cables are suspended below the main span in the form of parabolas, the vertices of which are about 4 ft. below the vertices of the four footbridge cables. The storm cables cross each other between the center and the point where they are secured to the columns of the main tower about 50 ft. above high-water mark.

The land spans are held by guys attached to the steelwork of the truss forming the end spans of the main bridge.

Calculations Necessary for Design and Erection.

In considering the design of the footbridge, the following conditions and requirements were known:

(1) Length of center span, *i. e.*, horizontal distance between towers;

(2) Length of land spans, *i. e.*, horizontal distance between towers and anchorages;

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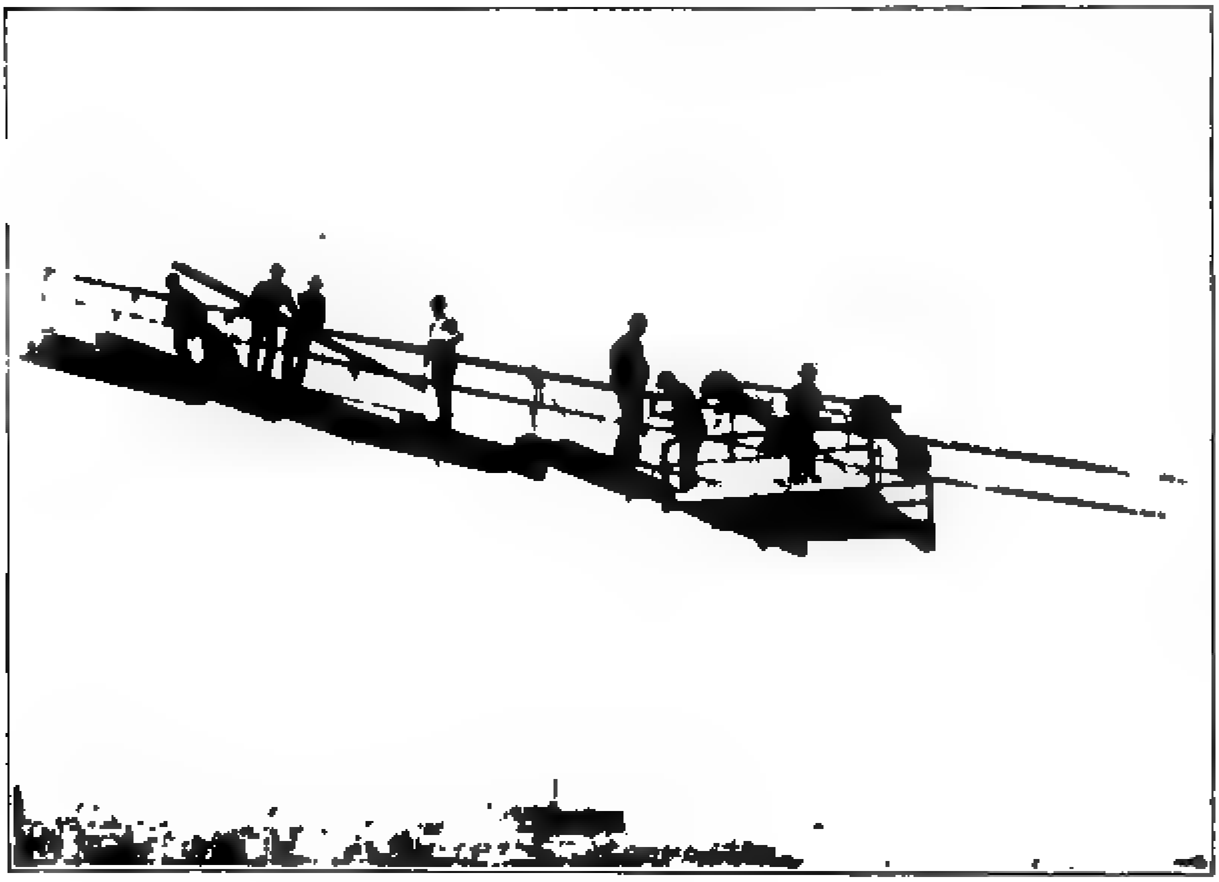

Fig. 1.—Erecting Main Span of Footbridge from Traveler.

Fig. 2.—Construction of Upper Deck of Footbridge.

(3) The exact position of the main cables when finished, and the exact position of each strand while being spun;
(4) The lower deck of the footbridge, when finished, must be about 4 ft. below the line of the main cable;
(5) The upper deck of the finished footbridge must be about 4 ft. below the line of a strand being spun;
(6) The floors of the two land spans when finished must be about 4 ft. below the line of the cable when in position;
(7) Each cable must be accessible from the footbridge at every point along its length.

The general design of the structure being decided upon, the preliminary step in the calculations was the location of the saddles on the towers and anchorages in order to determine the exact span and deflection of the curves.

The cable passes over two saddles on each tower, placed 6 ft. 8 ins. on each side of the center of the tower.

Therefore: Length of main span = 1 600—2 × distance from center of tower to tangent of curve on saddle.

The position of the tangent point was found approximately by scaling the drawing of the saddle after the line of the cable was laid off on it approximately at the correct angle.

The span being thus determined, the versed sine of the curve had to be found. The elevation of the tangent point on the saddle was known. The elevation of the center of the main cable at the middle of the span was also known. The distance below the center of the main cable to the bottom of the footbridge cable = 4 ft. + the thickness of the flooring, floor beams and footbridge cable. The versed sine of the loaded footbridge cable was thus determined.

The curve of this cable, after the footbridge had been built upon it, would approximate a parabola, and it had been found by experience that the formula of the parabola might be used here with practically correct results.

The load upon the bridge, while not exactly uniform per horizontal foot, is nearly so. The load due to the weight of the cables themselves is greater near the towers where the slope is steeper, but this is partially balanced by the additional weight of the timber work at the center of the span due to the increased distance between the upper and lower decks at that point.

The total load on the main span is made up as follows:

Timber work	718 000	lbs.
Rods, bolts, clamps, etc	87 800	"
Cables	222 000	"
Storm cables	55 500	"
Guys and storm cable suspenders	19 500	"
Traveling rope	7 200	"
Total	1 110 000	"

The load per foot $= \frac{\text{Total Load}}{\text{Span}}$, and the equation of the curve could thus be determined.

Next, it became necessary to find the equation of the curve of the main cable hanging unloaded. This cable, being of uniform section throughout its length, will hang in the curve of the catenary, the formula for which may be determined from the given position in which the cable is required to be suspended.

By computing an ordinate of the main cable and an ordinate of the footbridge cable at the same point, the position of the footbridge floor in reference to the footbridge cable was determined, and the operation was repeated at as many points as desirable. These ordinates were computed for every 50 ft., and the curve plotted on a scale of ⅛ in. = 1 ft. After the two curves were laid out, the line of the floor of the lower deck was drawn, it being a constant vertical distance below the main cable.

After plotting these curves it was found that the line of the lower deck floor of the footbridge nearly coincided with the curve of the footbridge cable for a distance of 400 ft. on each side of the center of the span. The beams of the lower deck floor, therefore, were attached directly to the footbridge cables for that distance. The lengths of the suspenders for the remaining 400 ft. to each tower were computed from the known ordinates at every 50 ft., and the intermediate ones were found by interpolation.

The next step was to locate the position of the upper deck. The floor of the upper deck had to be a constant distance below the strand while it was being made, this position of the strand being due to its temporary support in a position somewhat higher than that which it will occupy ultimately. Supporting the strand on sheaves over the saddles and holding the end of it back of its final position in the anchorage causes this condition.

FIG. 1.—TAKING TENSION ON TACKLE FOR FINAL PULL ON FOOTBRIDGE CABLE.

FIG. 2.—LAND SPAN OF FOOTBRIDGE AS SEEN FROM BROOKLYN ANCHORAGE.

This temporary suspension of the strand will allow it to assume the form of the catenary, the formula for which can be found, and the curve plotted on the same sheet with the other curves. The position of the upper deck floor may then be plotted also. Comparing the ordinates of the curve of the upper deck floor with those of the lower deck floor, the lengths of the posts supporting the upper deck may be determined.

On the land spans the difference in elevation between the cable in position and the strand being made was so small that a double deck was not necessary, as the strand in either position would be easily accessible from the same footwalk. The lengths of the suspenders in this span were readily computed by a comparison of the ordinates of the footbridge cable and the main cable in position.

Having settled upon the exact position and design of the finished footbridge, it became necessary to know in what position to suspend the unloaded cables, so that they might hang at the desired elevation after the weight of the structure had been placed upon them.

To arrive at this knowledge an inverse process of reasoning was necessary. It was assumed that the bridge was standing complete, with its cables in a known position and under a known tension. The length of the cable, under these known conditions, was computed from the equation of the parabola. Then it was assumed that all the load had been removed. The cables then would hang in the curve of the catenary. The average tension was then computed from the equation of that curve. The modulus of elasticity of the rope having been previously determined by tests, the difference in length of the cable for this known difference in tension was then found. The new length being determined, and the curve known to be a catenary, its versed sine was readily computed. The elevation of the points of support being known, the elevation of the vertex of the curve was found.

To suspend the cable at the correct elevation a leveling instrument was set up in one of the towers at exactly the elevation at which the lowest point of the cable should hang.

For the adjustment of the cables in the two land spans a similar process of reasoning was used to find the curve in which the unloaded cables would hang; but, as the vertex of the curve lies outside of the points of support of the catenary, the method of adjusting the cable by means of the level could not be used. In this case the transit had to

be used. It was set up at a known point between the two supports and in such a position that a line of sight could be taken tangent to the curve of the cable.

The equation of the tangent which passes through the point at which the instrument was to be stationed was found by previous calculation. The inclination of this line being known, the transit was set up and the telescope inclined at the correct angle of the tangent. In adjusting the cable it was only necessary to hang it so that its underside was tangent to the line of sight of the transit.

These calculations were all based upon a mean temperature. However, as the temperature plays an important part in the position of a cable of such length, it became necessary to make due allowance for such changes. The given position of the main cable unloaded formed the basis for all calculations as to the position of the footbridge. This position is given for a mean temperature of 60° Fahr.

The first figures obtained for adjusting the cables of the footbridge had to be tabulated for a temperature of 60° Fahr.

The elevation for which to adjust the cable in the main span for this temperature had already been determined. If it is assumed that the temperature on the day the cable was to be adjusted would be 1° higher, the increase in temperature would cause an increase in length, but the increase in length would also cause a decrease in tension. This decrease in tension had to be taken into account in determining the amount of stretch due to tension. The true length was thus found for the new temperature, and the deflection computed and tabulated. This was done for all temperatures which were likely to occur during the time of making the adjustment. In the case of the land spans a different tangent was found for the various temperatures, and its angle tabulated to be used as required.

Erection of the Cables.

The footbridge cable ropes were shipped by rail from Trenton, N. J., where they were made in the shops of John A. Roebling's Sons Company. They were transferred to the foot of the Manhattan tower on the deck of the largest tug of the Merritt, Chapman Wrecking Company. Each rope was 2¼ ins. in diameter, and about 3 020 ft. long. It came on a reel 7 ft. in diameter and 4 ft. wide, the whole weighing about 14 tons. A float, 180 ft. long and 25 ft. wide, previously used for

FIG. 1.—LAND SPAN OF FOOTBRIDGE DURING CONSTRUCTION.

FIG. 2.—VIEW OF MAIN SPAN OF FOOTBRIDGE, FROM TRAVELER.

the transfer of freight cars, was moored at the foot of the Manhattan tower. Three reels at a time were placed upon this float, mounted on stands bolted to the deck and placed so that the ropes could be reeled off over the side. Each reel was provided with a cast-iron brake rim over one flange of the drum, around which was passed two turns of 1½-in. manila line, one end being secured to the deck and the other held by hand.

The end of each rope was unfastened from the reel, raised over the tower, drawn back to the anchorage and secured there. This was accomplished in the following manner. The fall line from a derrick on top of the tower, operated by a hoisting engine on the float, was attached to the rope by means of a clamp about 60 ft. from its end. The end of the rope was then hoisted to the top of the tower. As the rope unwound from the reel, the loose part passed over the saddles and was placed in temporary rollers mounted on them. Plate XXXII, Fig. 1, shows the saddles for the main cable and for the footbridge cables, one footbridge rope, being in position and the other in the rollers ready to be pulled over. Another clamp was now attached about 10 ft. from the end of the rope, to which was connected a long line running back to the anchorage and operated by means of another hoisting engine located on the end-span truss about half way between the anchorage and the tower. After the tension had been taken on this "runner" the fall line on the derrick was relieved of its load and the clamp loosened on the rope so that it would slide down easily on the rope to the bottom of the tower. There it was once more clamped to the rope, and both engines were operated, one lifting it and the other pulling the end back to the anchorage. It was necessary to readjust the lifting clamp each time it reached the top of the tower, until the end of the rope had arrived at the anchorage.

The socket was next put on and the connection made to the short piece of rope previously secured to the anchorage girder. This operation was repeated until all three ropes forming a cable were similarly placed. Each in turn was removed from the rollers on top of the saddles and lowered into place in the saddle.

The next operation was to get these ropes across the river. This was accomplished with the assistance of three powerful tugboats, which towed the float across the river at slack tide. This time was selected because the course could be more easily controlled and be-

cause at that time vessels could be more easily handled and kept out of the way. The float was towed sideways, with a tug at each end and one ahead to pull. The operation of towing the float across the river is shown in Plate XXXI, Fig. 2. The course was kept as nearly as possible in a straight line between the two towers, and, as it was traversed, the reels were allowed to pay off the rope, which sank and lay upon the bed of the river, the ropes having been previously lashed to the bottom of the Manhattan tower.

The trip across the river occupied about 14 minutes, during which time great care had to be exercised that the reels did not pay off too rapidly. When the Brooklyn side was reached, the float was moored to the tower. It was then found that about 400 ft. of rope remained on each reel. This was unreeled, one reel at a time, and laid along the full length of the deck of the float. About 60 ft. from the end of the rope a clamp was secured, to which the fall line from a derrick on the tower was attached. The engine on the float operated the line and hoisted the end of the rope to the top of the tower. The loose end was next passed over the tower and placed on the rollers on top of the footbridge saddles. Another clamp was placed near the end of the rope, to which was attached one end of a three-part, $\frac{5}{8}$-in., wire-rope tackle, which reached to the Brooklyn anchorage, and was operated by a 60-H. P. hoisting engine there. The clamp was removed from the river side of the rope as it lay over the saddles. The lashings which held it near to the foot of the Manhattan tower were cut, and everything was then in readiness to raise the rope from the bed of the river, and stretch it from tower to tower. Two government patrol boats guarded the river to prevent passing craft from interfering with the operation, which was performed at slack tide.

At a signal from a steam whistle on the float (the signal also serving as a warning to passing boats), the engine on the Brooklyn anchorage began to pull the rope over the tower, and gradually drew it from the river bed until it had been raised nearly to its correct position. This operation consumed from 4 to 6 minutes. By this time the upper block of the tackle had traveled to the Brooklyn anchorage. The main span was now so nearly balanced with the Manhattan land span that workmen on top of the Manhattan tower, were able, by means of a set of hand tackle, to pull the rope over the tower until it was correctly adjusted.

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Fig. 1.—Lower Deck of Main Span of Footbridge.

Fig. 2.—Main Span of Footbridge with Storm Cables and Guys in Place.

A man with a transit stationed at the correct point below the curve fixed the position of the rope according to the temperature. Once adjusted, the men on the tower marked the rope in its correct position, and secured it against future movement.

At the same time an additional clamp was being placed on the end of the rope which had been pulled down to the Brooklyn anchorage. This was placed a little above the other clamp, and, attached to the former, was a nine-part manila tackle with its other end secured to the short rope fastened to the anchorage girder. A tension was now taken on the manila line by the engine, and the tension on the wire-rope tackle relaxed and the clamp removed. The operation of taking the tension on the nine-part tackle for the final pull on the footbridge cable rope is shown in Plate XXXIV, Fig. 1. In the meantime the rope was lowered into the saddle on the Brooklyn tower, and everything was made ready for the final pull.

A man with a level stationed in the Brooklyn tower at the correct elevation according to the temperature, gave the signals to raise or lower the rope until it hung at the correct height over the middle of the river. When this was adjusted, the position of the rope was marked on the Brooklyn tower, and secured against future disturbance.

The next step was to adjust the Brooklyn land span. This was done, as on the Manhattan side, by means of a transit set at the correct angle. The rope was lowered or raised to the correct position, which was marked on the saddle at the face of the anchorage as soon as adjusted. The rope was then measured and cut off, the socket put on and connected to the short rope fastened to the anchorage girder.

This completed the stretching of one of the footbridge cable ropes. The operation was repeated until twelve ropes, assembled into four cables, were similarly suspended. The adjustment of the subsequent ropes was made by comparison with those previously adjusted, but all were finally checked independently.

Erection of the Superstructure.

The placing of the timber work was begun at each tower, and worked downward toward the center on the main span, and toward the anchorages on the land spans. Each piece was framed and marked as to its location in the structure before being hoisted from

the ground. Two travelers for the main span were first erected, at each tower, and two for each land span. In each case a traveler ran on two cables by means of grooved wheels connected by an axle to which was suspended a platform large enough to accommodate four or five men. The cable bands, suspender rods and floor beams were attached to the cable by the men on the traveler. The traveler was allowed to run down the cable in advance of the work. The traveler is shown in Plate XXXIII, Fig. 1. Another gang followed up the traveler and laid planks across the floor beams as fast as they were swung into place. Plate XXXV, Fig. 2, is a view from the traveler on the main span, looking back at the work just placed. In the main span the material was carried down from the towers by hand, but on the land span each bent was framed complete on the truss below and hoisted up and connected to the cables by the men on the travelers. Plate XXXV, Fig. 1, is a view of one of the land spans during construction, in which the travelers have advanced about half way to the anchorage. It was necessary to keep the work on the two sides of the tower well balanced, so as not to cause the cables to slip over the saddles from undue loading in one span.

The travelers advanced toward the center of the main span simultaneously from each tower, so that the meeting point was at the center. When this point was reached the travelers were taken apart and carried back over the footwalk to the towers.

A view of the main span from below, at the level of the roadway in the tower, is shown in Plate XXXVI, Fig. 1.

The land span travelers were run down to the anchorages, and taken apart there. Handrail posts were next bolted to the floor beams, and a ⅝-in. galvanized wire rope for a handrail was stretched along the full length of each footwalk.

Before commencing to erect the upper deck of the main span four additional 2¼-in. ropes were suspended. These ropes were drawn across the bridge from the Manhattan tower, the reel being placed at the foot of the tower. This pulling was done by an engine on the Brooklyn anchorage with a ⅝-in. plough-steel line, passing over the Brooklyn tower and running on the sheaves on top of the footbridge saddles. Each of the four ropes was hung just above one of the footbridge cables, and rested in the same saddle at the top of the tower. These ropes were suspended at a certain elevation so as to be just

PLATE XXXVII.
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FIG. 1.—MAIN SPAN OF FOOTBRIDGE, SHOWING ERECTION OF UPPER DECK.

FIG. 2.—COMPLETED FOOTBRIDGE.

below the floor beams of the upper deck, and carry their proportion of the load of the bridge. In each land span they were drawn down and clamped to the other three ropes forming a cable. Plate XXXIV, Fig. 2, is a view of the land span of the footbridge, as seen from the Brooklyn anchorage, as it passes through the steelwork of the end span.

The erection of the framework for the upper deck was begun at the center of the main span and carried toward the towers. Plate XXXVII, Fig. 1, is a view of the main span, showing the erection of the upper deck. The material was run down on top of the cable by bridgemen who held each end with a line and ran along the footwalk with each piece, as shown in Plate XXXIII, Fig. 2. When the posts, stringers and floor beams were in place, the 2 x 6-in. flooring was laid over the beams, beginning at the towers and working toward the center. The flooring on the land spans was similarly laid. Handrails of ⅝-in. galvanized wire rope were stretched on each side of every footwalk, and secured to the handrail posts with staples.

Half way between each anchorage and tower and at three points along the main span were erected frame towers about 12 ft. high. On these were supporting sheaves over which ran a traveling rope.

STORM CABLES.

The four 2¼-in. storm cables previously described, each about 1 700 ft. long, were delivered on reels at the foot of the Manhattan tower. The free end was taken to the top of the tower, passing up the land. side, and crossing over the top toward the river on the sheaves on top of the footbridge saddles. The rope was now drawn across the footbridge in the same way as were the cables for the upper deck. They were laid across the lower deck beams and in such a manner that they could be easily pushed overboard. While in this position a suspender of ½-in. galvanized wire rope was fastened every 40 ft. The other end of the suspender was attached to the foot-bridge cables. The length of each had been regulated by previous calculations, so that when the storm cable became suspended by them it would hang in the form of a parabola.

When all the suspenders were properly connected the cable was lowered overboard by means of blocks and falls at numerous points until it was hung on the suspenders. The two ends were then pulled

in to each tower, and sockets placed upon them. Each was secured to one of the main posts of the tower and screwed up to the proper tension by means of long U-bolts. A view of the main span, with the storm cables and guys in place, is shown in Plate XXXVI, Fig. 2. The footbridge was secured additionally by means of long guy ropes which ran from the main span down to the towers.

Plate XXXVII, Fig. 2, is a view of the completed footbridge as seen from Brooklyn, just back of the anchorage. When the structure was completed, observations were made to determine how near the bridge came to occupying the position for which it was finally intended. The result of the observations showed it to be within a very few inches of the calculated position, which was a great source of gratification to the engineers in charge, as it proved the correctness of the assumptions, the exactness of the intricate calculations involved, and the accuracy of the instrument work.

When the last wire in each main cable had been laid and the last strand adjusted, the usefulness of the upper deck of the footbridge was at an end. The whole of the upper deck work was then removed, the flooring being transferred to the lower deck and the other timber work being kept on the span, so as not to change the loading and consequently the position of the bridge. The upper cables were tied to the lower ones by long U-bolts, so as to make each carry a proportion of the load.

The work of putting on the cable bands and cable covering, and hanging the suspenders, can now be completed from the lower deck of the bridge.

The expectations of what the footbridge would accomplish have not been over-estimated, for it has permitted a saving of much time made the work safer, and afforded a means of building the cables as nearly perfect as it is within human possibility to do. The erection of such a bridge may be usually considered a very hazardous occupation, but in this case not a single accident occurred.

Reference to cable making, except in explanation of the functions of the footbridge, has been purposely omitted in this paper, as that is a subject in itself.

Vol. XXVIII. SEPTEMBER, 1902. No. 7.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

A PROPOSED NEW TYPE OF MASONRY DAM.

Discussion.*

By Messrs. George H. Pegram, J. Breuchaud and A. V. Abbott.

George H. Pegram, M. Am. Soc. C. E.—The form of dam proposed by the author aims at a saving of masonry, but its main advantage seems to be in the marked increase in overturning resistance shown in his table of comparisons with the Wegmann forms. It also has the advantage claimed by the author of greater stability against the upward pressure of water leaking under the dam. Mr. Pegram.

The type proposed seems susceptible of very neat calculations, but this is not an important consideration in dams of magnitude.

The Pioneer Electric Power Company, of Ogden, Utah, of which the speaker was Consulting Engineer, studied the question of a 100-ft. dam for the Ogden River, and some of the results are given in a paper by Henry Goldmark, M. Am. Soc. C. E.†

At the time the speaker's attention was called to the matter, the company had prepared designs for the ordinary gravity section and also for a steel dam with a vertical face, and it was suggested that in any dam where the weight of masonry is reduced the up-stream face should be inclined so as to use the weight of the water, and it is thought that this suggestion might apply to the form submitted by the author of the paper under discussion.

In the case of the Ogden Dam the walls of the cañon are so pre-

* Continued from August, 1902, *Proceedings*. See April, 1902, *Proceedings*, for paper on this subject by George L. Dillman, M. Am. Soc. C. E.
† *Transactions*, Am. Soc. C. E., Vol. xxxviii, pp. 290 and 302.

Mr. Pegram. cipitous that a diversion of the river seemed a serious question, and the location of a city at the mouth of the cañon made it especially desirable to design a dam which would be as absolutely safe as due considerations of cost would permit. The speaker suggested that a form be tried having isolated piers connected by arches with impervious faces, a form of which is given in Mr. Goldmark's paper; the objects to be accomplished being:

1.—The construction of piers independently, thus avoiding the necessity of a diversion of the river;

2.—The securing of an impervious face to the dam;

3.—The avoidance of uplifting pressure by water that might leak under the dam;

4.—The ability to get a better class of masonry by building it in smaller masses than in the ordinary dam;

5.—Less total cost.

Cracks in concrete are apt to be long, and hard to stop, and therefore the necessity of a steel plate on the up-stream face. Large steel plates, at the time, could have been bought at a trifle more than one cent per pound, and the speaker proposed a design having isolated piers of triangular form with an up-stream slope of 30°, 11½ ft. thick, and spaced 23 ft. in the clear, the up-stream face being a continuous steel plate corrugated with radii of 7 ft. over the piers' ends and 14 ft. between the piers, the up-stream toe to be enclosed in a wall of concrete, 15 ft. thick and 25 ft. high, enclosing horizontal angle-irons riveted to the steel plate to assist by its weight in resisting the overturning effect.

Mr. Breuchaud. J. Breuchaud, M. Am. Soc. C. E.—It is somewhat difficult to give an off-hand estimate of the cost of the masonry in the author's dam as compared with that in a dam of the ordinary section; but the speaker believes the cost would be greater, because it would require a high grade of work, with deep, close-cut beds and joints, to ensure anything like a reasonable degree of water-tightness in such a thin wall as that proposed.

Mr. Abbott. A. V. Abbott, M. Am. Soc. C. E.—The speaker has had little experience in the actual construction of masonry dams, but has had considerable in the endeavor to construct masonry in such a manner as to make it completely water-tight; and so it appears to him that the points made by Mr. Pegram are exceedingly well taken.

There are two aspects of engineering: One, the theoretical point of view, and the other, the adaptation of the design indicated by theory to practical conditions. There appears to be little doubt that a dam or other structure intended to enclose water could be designed with a more economical section, upon the principles developed in this paper and discussion, than according to the ordinary methods. Doubtless there would be a considerable saving in the

actual quantity of masonry; but when the problem is presented of making water-tight a structure so thin as would be called for if the principles of this paper were followed out, a very difficult problem is introduced, and one for the solution of which quantity of masonry rather than strength of construction is required. It also seems that the subdivision of a dam into a number of buttresses, as is demanded by the plan proposed in the paper, is likely to introduce such a complication of stresses as will make accurate determination thereof, even theoretically, an exceedingly difficult problem, and one which is entirely incapable of solution under ordinary practical conditions. Mr. Abbott.

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PAPERS AND DISCUSSIONS.

IMPROVEMENT OF THE BLACK WARRIOR, WARRIOR AND TOMBIGBEE RIVERS, IN ALABAMA.

Discussion.*

By Messrs. WILLIAM L. SIBERT, D. A. WATT, GEORGE Y. WISNER and JOHN M. G. WATT.

Mr. Sibert. WILLIAM L. SIBERT, M. Am. Soc. C. E. (by letter).—Mr. McCalla's paper presents in detail a subject about which there is very little literature. The conclusions, however, which have found expression in the plans presented in the paper, are very different in some important particulars from the conclusions to which the writer's experience has led him.

These particulars will be the subject of this discussion.

Lock Location—Guide and Guard Walls.—On this subject Mr. McCalla states as follows:

"Locations were sought in wide, shallow places with good, high banks, and in curved instead of straight reaches. The locks are always located on the convex shore, in order to secure better protection from the drift during floods, and on straight approaches parallel to the axis of the lock re-entering the stream."

The proposed guide and guard arrangements for entrance and exit are as follows: A paved slope, 2 ft. on 1 ft., above the lock, and a line

* This discussion (of the paper by R. C. McCalla, M. Am. Soc. C. E., printed in *Proceedings* for April, 1902), is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.
Communications on this subject received prior to October 25th, 1902, will be published subsequently.

of pile clusters below. The guard arrangement above the lock is a line of pile clusters flaring toward the middle of the stream, with nothing below. See Fig. 16. Mr. Sibert.

The writer's experience leads to the following:

A lock with a fixed dam should be located, if practicable, in a wide straight reach of the river. If forced to locate a lock and dam in a bend, by foundation or other conditions, the lock should be placed on the convex side of the bend. There should be a guide wall, having the inside face vertical, on the land side of the entrance. The alignment of this wall should be such that boats alongside of it can enter the lock without material change of direction. The least length should be such that boats can come alongside of it before the head of the craft comes into the dead water at the entrance. The maximum length should depend on the rapidity with which it is necessary to operate the lock. Where a lock is taxed to do the business, the guide wall should be long enough to allow boats to come alongside and be in position to enter the lock, so that no delay will result when the lock is ready for a boat. Mooring piers, for boats awaiting lockage, are necessary, and guide walls, when long enough, form the most convenient piers.

The guard wall should be solid, with possibly a short drift gap next to the head of the river lock wall, and should be of such length that one lockage lying inside of it will be safe if cut loose from the steamboat. The solid wall will deaden the water in the entrance so that barges can be taken into the lock by hand. This wall should flare slightly toward the middle of the stream, but not enough to create an appreciable eddy below the dam near the lower entrance to the lock. This flare should be prolonged by pile clusters. A paved slope immediately above the lock is objectionable, for the reason that the wheels of boats will be damaged by striking upon it.

A guard wall made entirely of clusters of piles from 30 to 70 ft. apart, makes the entrance to the lock very difficult and dangerous. When the water is high, the draft of the water between the pile clusters pulls everything hard against the clusters, making it impracticable to place barges in the lock by hand. The forward outside corner of a barge is likely to be drawn in behind a cluster, and a steamboat would be forced to put out a line to get the barge out.

The guide wall below the lock should be solid, with the inside face vertical. Its height should be such that it will be flooded at the same time that the upper end of the lock wall is flooded; its length to be determined in the same way that the length of the upper guide wall was determined.

Guard walls on the lower end of the river lock walls should be avoided where possible. Where the dam is not located near the head of the lock, and when the lock is short, the reaction sometimes forces

Mr. Sibert. the construction of such a wall. It is absolutely necessary that gates be mitered properly, and when there is any danger that the reaction below the dam will disturb this mitering before enough head is on the gates to hold them together, a guard wall should be built. In the writer's opinion, some of the recent failures of wooden lock gates are due to this cause. This reaction disturbs the miter after there is some head on the gates, and drives one of the leaves up stream, as shown in Fig. 21. The pressure on the upper side of the other leaf forces the upper part of that leaf down stream, so as to come in contact with the miter post of the opposite leaf, as shown. As the water rises in the pit the leaves are held in that position, and one leaf is forced by the other when the head is sufficient. A guard wall below the lock, with the guide wall, forms a pocket which is always full of drift during a rise, which, of course, is a nuisance.

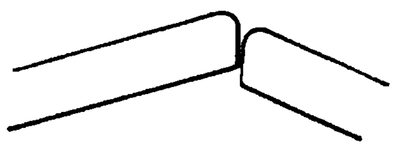

FIG. 21.

In order to discuss the question of lock location in a bend, assume that one lock is located on the convex side and one on the concave side. The lock located on the convex side, Fig. 22, has the guide and guard arrangements proposed in Mr. McCalla's paper; that located on the concave side, Fig. 23, has such guard and guide arrangements as are thought necessary.

Let it be assumed that a towboat navigation is to be especially provided for, or such as will predominate on the Warrior system. The various positions of a tow entering the lock for both locations are shown on Figs. 22 and 23.

It is seen that a tow in entering the lock on the convex side is forced to keep the stern of the towboat next to that side, for if the stern gets out into the stronger current it is difficult to prevent the tow from rounding to. In high water, when boats have their full capacity of tow, this can only be done safely by the use of a line. Assuming, however, that it can be done without a line; when the boat and tow are in the position shown at A, it is then necessary to back the stern of the boat out, thus swinging the tow in the entrance. Such an operation in a swift current just above a dam is exceedingly dangerous, and, if attempted without the use of a line, will result in many tows going over the dam.

It is also difficult to enter the lock on the convex shore in low water. When the tow is in the position A it is necessary to throw the rudders away from the shore in backing to get the tow in shape to enter. With a stern-wheel boat, this soon gives rise to a down-stream current on the land side of the tow, due to the rudders deflecting the current made by the wheel. This current is again deflected by the bank and dead water at the head of the entrance, and it has a tendency to push the head of the tow outside of the entrance. The stern of the boat is already swinging out into the river, with the result that the

entire tow gets into such a position as to force a beginning over again of the operation of entering the lock. Mr. Sibert.

Now, upon examination of the positions of the tow entering the lock on the concave side, it is seen that no lines are necessary, and no unusual difficulties presented. The current naturally takes the boat and tow in toward the shore. It may be necessary to back the stern out to keep off the shore, but in this operation the rudder is thrown toward the shore and the extra current generated is thrown on the river side of the boat and tow.

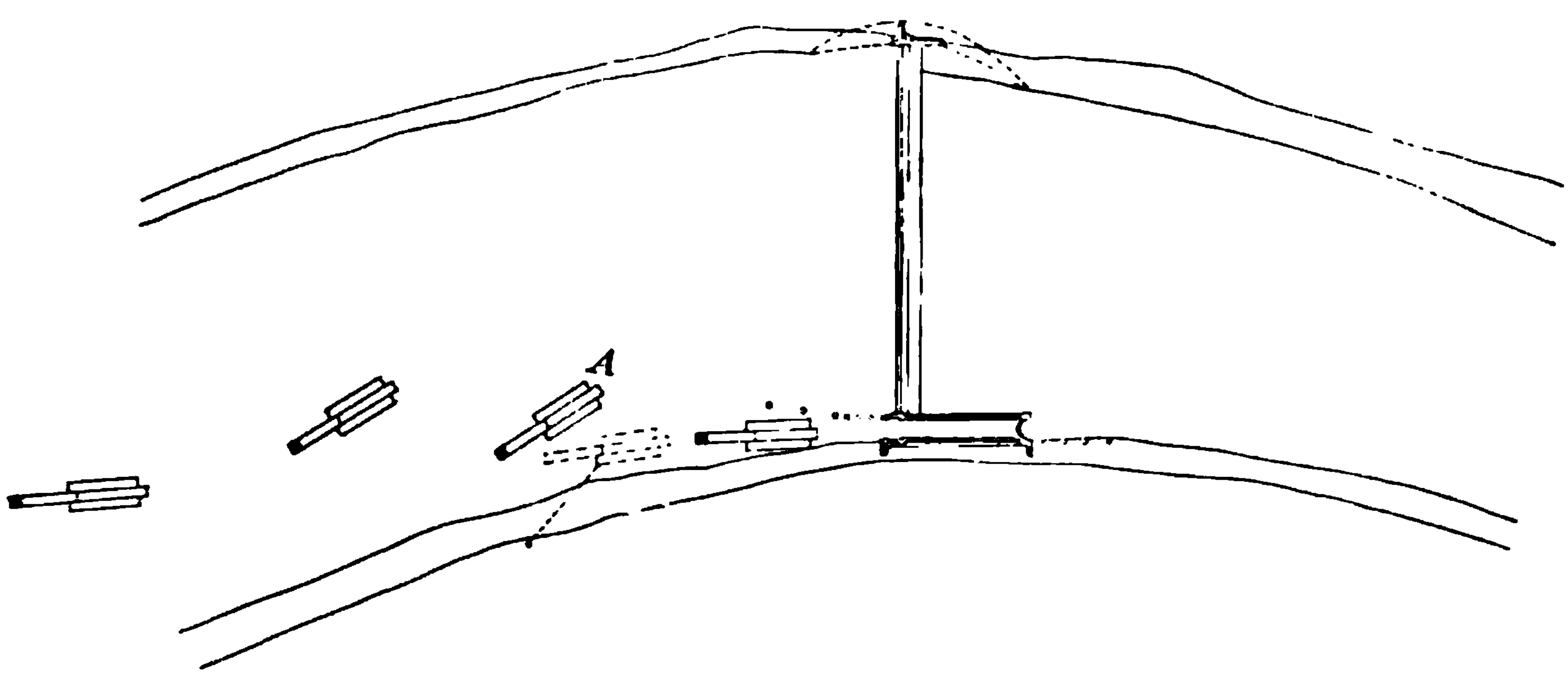

FIG. 22.

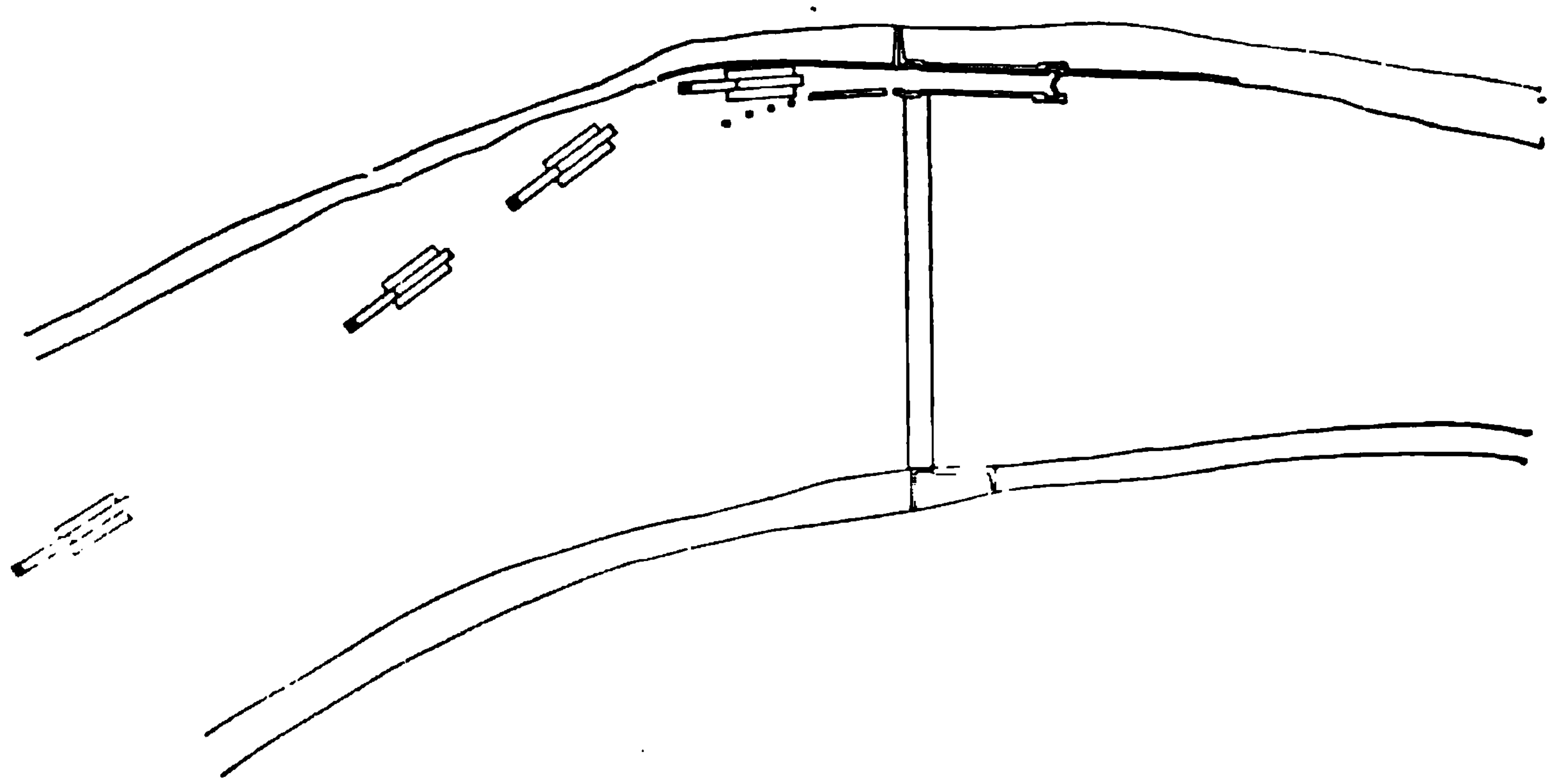

FIG. 23.

It may be more difficult to get out of the lower entrance of a lock located on the concave side, but there is no danger attached to it. Safe navigation should be the first consideration in lock location.

Regardless of the safety of navigation, the location of a lock on the concave side of a bend is still preferable to the convex side. The convex side is always shallow. The deposit naturally made on this side can

Mr. Sibert. be dredged away, but the same conditions that placed it there in the first place will replace it when removed. Of the two evils, drift or the silent process of deposit of silt during rises, the former is more easily dealt with. An alert lock force can steer all drift over the dam. The dead water in the head of the lock will facilitate it, but the silting up of the entrances cannot be stopped, and, after a rise, a dredge will often be necessary before a lock can be put into service.

A straight wide reach of river is free from the disadvantages of a bend location with the lock on either side. A lock should be so located, and the dam made of such height, that no dredging will be necessary in the upper ends of the pools in order to produce the requisite depths. Such dredging is a continual expense. The resulting channels are always narrow, and interfere with the full use of the river for towboat navigation. The greatest amount of deposit is produced in the upper ends of the pools. The slackening up of the current below the dams on a rising river, until the water piles up enough to create a slope sufficient to carry the discharge, causes a deposit of heavy material in the reaches just below the dams. This makes it evident that the full depth should be made in the beginning.

It has been the history of all improvements that, as soon as the improvement is completed, the navigation interests begin to clamor for more depth, as the profits of transportation vary directly with the depth. One way of giving this depth is by dredging in the upper end of the pool, and, in view of such a contingency being forced by legislative action, it is always well to make the pool depths by the dams in the beginning, and to place the sills below the protected navigable depth.

Dams.—The decision to place fixed instead of movable dams in the Warrior River, in the writer's opinion, was wise. The disadvantages of movable dams are many. They are frail structures; the likelihood of serious accident on account of drift and ice has rendered it necessary to keep the Davis Island Dam, on the Ohio River, down for at least six months in the year, from December to May, inclusive. During this time there is often low water, with the result that there is not enough water for the transaction of the river business in the pool above the dam, which includes the Harbor of Pittsburg. When it is remembered that a line of transportation must be in operation practically all the time, in order to develop its full use under modern conditions, the almost fatal defect of a movable-dam system seems apparent, and its use should be limited to particular cases. Such cases should be: Rivers in which there is nearly always sufficient water for the business during the winter and spring seasons, unless some more efficient system of movable dams can be devised. Such a system should be one that can be surely lowered before the drift or ice of a sudden rise can catch it, and one that can be raised and maintained

Mr. Sibert.

Sand and Gravel

TYPE OF DAM, ALLEGHENY RIVER, (HEAVY ICE IN THIS STREAM.)

Fig. [illegible]

Fig. [illegible]

Fig. [illegible]

Fig. [illegible]

Mr. Sibert. notwithstanding such drift or ice as may be running when the stage of water is reduced below that needed for the most economical transportation of commodities.

In the upper reaches of all rivers where quick rises occur, fixed dams with long locks, as wide as practicable, seem to be indicated as the best system. In the lower and flatter reaches movable dams may be the best.

Type of Fixed Dam.—Figs. 24 to 28 are cross-sections of the dam proposed in the paper, and of dams which the writer considers good types. There is also shown a cross-section of the type of the first fixed timber dams built in this country.

Generally speaking, the less upper slope on a dam, the less leakage area; it being impracticable to maintain an efficient backing on such slope. In the earlier types of dams, the upper slope extended from the crest to the river bottom, the idea being to make the water pressure increase the stability of the dam. Leakage was abundant, of course, and such dams could only be maintained on hard rock bottoms.

A gradual change from this type to those generally adopted now is seen in the various dams built for slack-water purposes in this country in the last sixty years, the length of the upper slope decreasing and of the lower slope increasing.

An examination of the section proposed by the author shows, so far as it can be seen, that every possible attempt has been made to box in any leakage that may find its way through the upper face of the dam. The lower slope is double-lapped and caulked, triple-lapped sheet-piling is driven along the down-stream edge of the dam proper, the lower breast is sheeted, the sheeting on the apron is double-lapped, and triple-lapped sheet-piling is driven along the lower edge of the apron.

In the foundation for the lock, Mr. McCalla's plan wisely provides for relieving the floor from any pressure from the upper pool due to leakage through the triple-lapped sheet-piling; why the same principle was not applied in the dam design, is not seen, when it is known that it is practically impossible to make the filling of crib dams absolutely impervious to water. The sheet-piling at the lower edge of the dam and apron, in the plan presented, is an acknowledgment of this fact.

In the sections showing types of dams on the Green, Kentucky, and Allegheny Rivers, the dam is made by the upper breast and slope. The remainder of the structure is for the purpose of holding the upper breast and slope to their work, and for controlling the flow of the water over the dam in such a way as to protect the structure itself from the action of the water under the imposed conditions of flow; also, to reduce the disturbance below the dam, for reasons affecting navigation.

The sheeting on the lower slopes of these dams is of one thickness of timber, placed so that there will be a 1-in. opening between the pieces of sheeting at the lower end of the slope. This opening may be gradually decreased to nothing at the comb of the dam. Mr. Sibert.

The lower breasts of the dams and aprons are of open crib work, and the pieces of sheeting on the apron are spaced 1 in. apart; the idea being to let out any leakage that gets into the body of the dam.

The writer has seen two cases where the sheeting (not double-lapped, but laid close on the aprons) was taken off; and several cases of lifting of the lower slopes of dams, due to close-fitting sheeting.

Assuming a leakage through the dam and under the apron, as proposed in the paper, a simple calculation will show that the pressure to be resisted by each holding-down driftbolt in the apron (there being one in each pile, 9 ft. each way) will be excessive.

No reason is seen for a pile foundation for a timber crib dam, unless it be the cost. If a concrete dam, or an ultimate rebuilding in concrete, is contemplated, there is a reason, and a section for such a dam is shown in Fig. 28. In the design of this dam, the reduction of the cost of the coffer-dam to a minimum was aimed at, and it is thought that such a dam can be built at low cost. The timber foundation for the concrete top can be built without the use of a coffer. The concrete base, a section at a time, as high as low water, can then be put in behind the bulkhead made by the projecting sheet-piling. In building the remainder of the dam, a sufficient number of openings (each about 10 ft. wide) to carry the low-water discharge should be left. With this arrangement, no head will be produced at the dam until the closing of the 10-ft. openings is commenced. Beams across these openings having been placed while building the contiguous sections, little trouble should be experienced in bulkheading off these openings so as to fill them with concrete.

Length and Lift of Dams, and Height of Lock Walls above Crest of Dams.—This is a subject about which there has been very little theoretical discussion, so far as the writer knows. The available data for such a discussion are very meager.

The result desired is to apportion the foregoing elements of lock design so that, when the lock walls are submerged, navigation over the dam is practicable.

It seems to have been solved in the paper by adopting a uniform lift, uniform height of lock wall above the crest of the dam, and a uniform length of dam. Apparently, the length of the pools above and below the dams, which depended of course upon the slope of the unimproved river, was left out of consideration. This element is a very important one.

Mr. Sibert. The lift and height of the guard wall at Lock No. 1, Black Warrior River, being such as to practically produce the required condition, a similar lift and height of guard wall was adopted for the Warrior system.

An examination of Fig. 1 shows that the length of the pool below Lock No. 1, Black Warrior, is 46 miles; the five upper pools in the Warrior River vary from 15 to 21 miles in length. In view of the fact that the fall at the dam is due, not only to the height of the water surface at the crest of the dam, but to the elevation of the water surface just below the dam, which latter condition is determined by the slope necessary for the discharge of the flood through the pool below, it seems to follow that, since a greater elevation of water at the upper end of a long pool is necessary to produce a certain slope than is necessary in a short one, boats cannot ordinarily go over the dams in the Warrior River when the lock walls are just flooded.

The effect of lengthening the dam by digging away the bank locally, as shown in Fig. 16, can very easily be over-estimated.

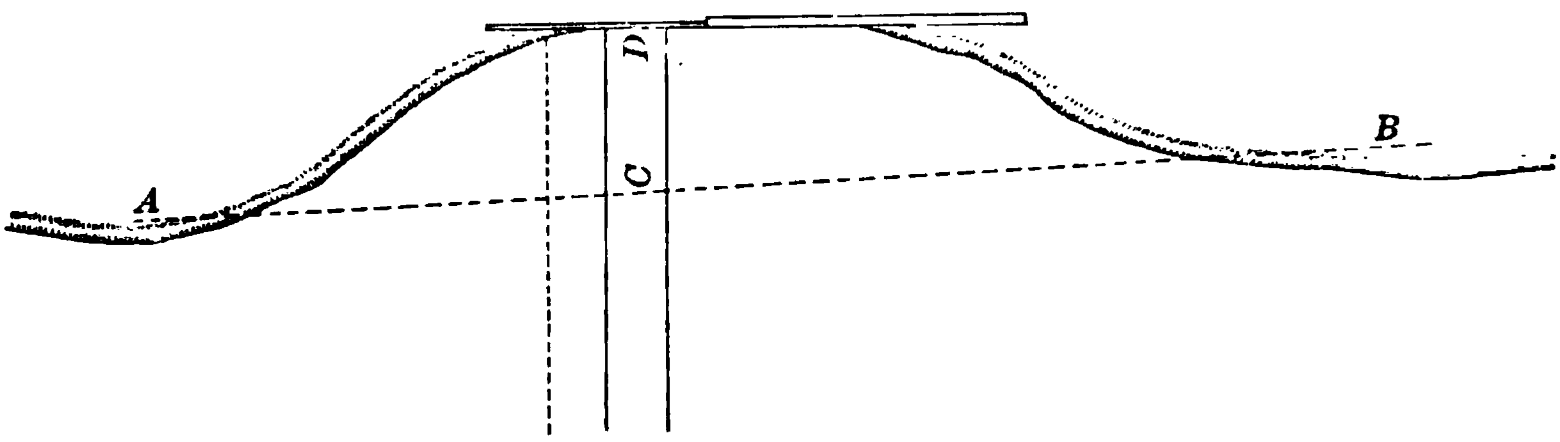

FIG. 29.

Dam No. 1, on the Monongahela River, Fig. 29, is now of about the same design as proposed in the paper. This condition was produced by the unauthorized building out of the banks above and below the dam. The question is: What difference would it make if the bank was filled out to the line A — B? It is noticed that during flood stages the fall at the dam is considerably less from C to D than it is along the remainder of the crest. Boats often go over the dam from C to D, when they cannot go over the other part. This seems to show that the effect of this local widening is not felt entirely across the river or for any distance above. The effect of such a widening will vary somewhere between that apparently expected and that produced by filling once the extra space. To produce the expected result, the channel of the river above should be gradually widened to the dam. The probable effect of the sudden narrowing of the channel below the dam, in the manner indicated in Fig. 16, will be that the water will be deflected toward the opposite shore and increase the violence of the eddy that will exist below the lock. This eddy passing through

the pile clusters will cause difficulty in entering the lock from below. Mr. Sibert.

There are not many points in the construction of the lock itself that vary materially from the practice with which the writer is accustomed. Some few are worthy of mention, however.

On the Monongahela River, in building concrete locks, work on the 20 to 30-ft. blocks or monoliths is never stopped, night or day, until the monolith is completed.

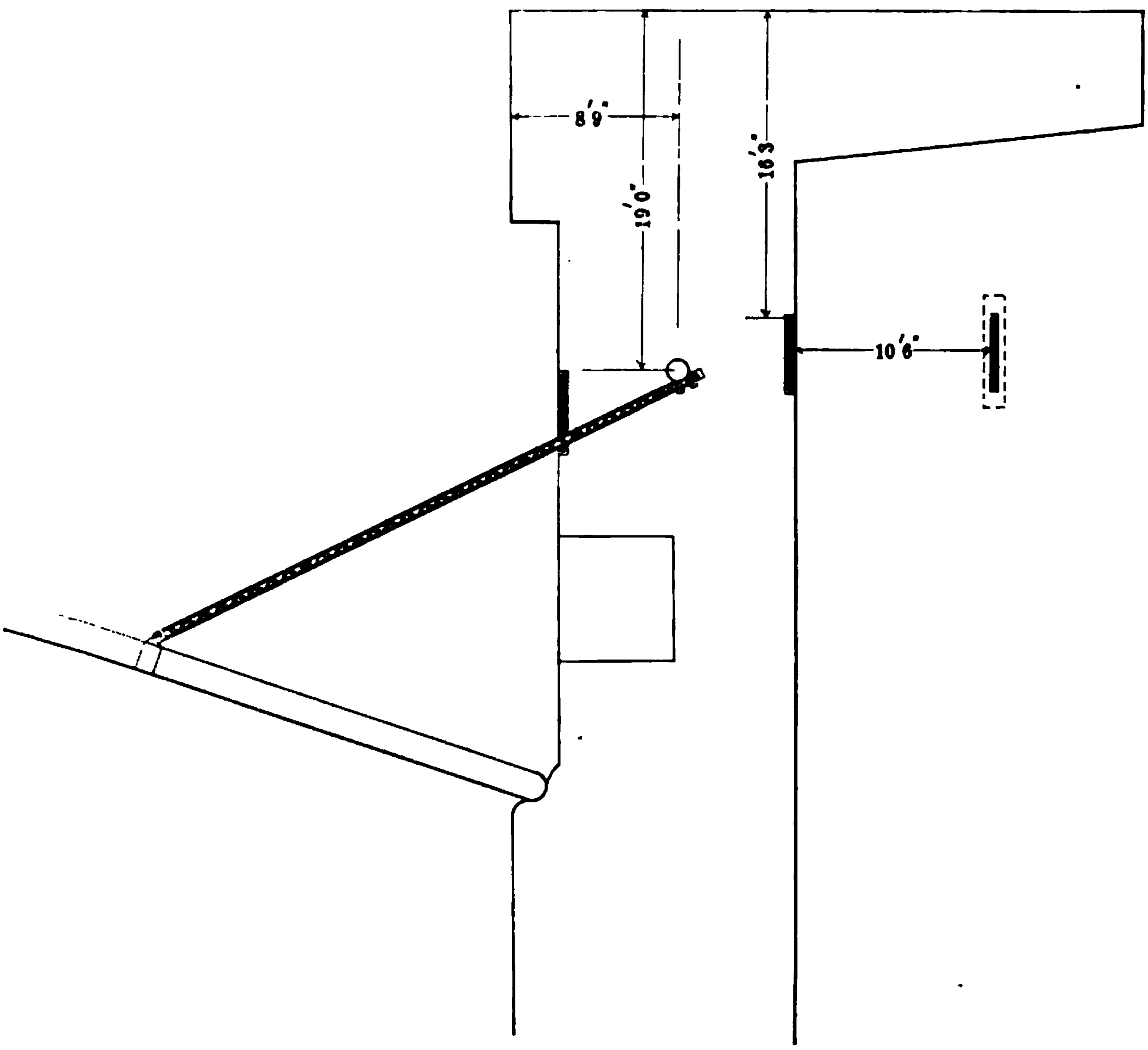

FIG. 80.

Scour below a dam is greatest next to the lock wall and abutment. Sometimes a fill will be noticed in the center of the stream, while a deep narrow channel will be made along the lock wall, due probably to the guiding effect of the wall. In some instances on the Monongahela River this cut is 25 ft. deep. This would indicate that the penetration of the sheet-piling to a depth of 12 ft., as shown in the plan, was not sufficient, unless a submerged protection crib was built alongside and outside the lock wall.

Mr. Sibert. The method of opening the gates is a departure from the usual practice, and an undesirable one, it is thought. It has the appearance of taking hold of the wrong end of the gate. Of course, it is possible to apportion the lever arm and force in such a way as to overcome the calculated resistance, but there is often an uncalculated resistance, due to the jamming together of the miter posts, especially when these posts are somewhat old, that is difficult to overcome by a force applied near the resistance. In starting gates thus jammed, on the Monongahela River, ¾-in. chains have been broken, the point of application having been near the toe, and not at the heel. The usual methods, viz., by a rack spar working in a pinion on a capstan, Fig. 30, or by a spar and rope seem preferable in medium and small-sized locks. In the larger locks, opening and closing the gates by chains is the usual practice.

Mr. D. A. Watt. D. A. WATT, M. Am. Soc. C. E. (by letter).—This paper will prove of much interest to engineers connected with works of canalization, because, outside of the reports of the Chief of Engineers of the U. S. Army, very little information on the subject is accessible.

One feature of the foundations is worthy of note, namely, the omission of a timber floor on the piles under the main walls. This is a practice which is not often met with in the design of locks, the usual method having been to drift-bolt caps to the heads of the piles, and spike on a plank flooring on which a concrete foundation course is commenced. By this method, however, the entire weight of the masonry has to be carried by the piles, and the additional support which could have been obtained from the natural foundation, if the concrete had surrounded the pile heads, is not turned to use. Besides this, the strength of the work depends on the ability to resist crushing of those parts of the caps which rest on the piles, and through which all the load must pass. While these may be strong enough when dry, they become weaker when wet, as experience has shown that timbers long submerged and under pressure become softened by the water. It is probable that the cracks, which have appeared after a lapse of years, in some walls built on pile foundations, have been due to this cause.

The design of the floors of locks is sometimes open to similar criticism. These portions, which are so vital a point in the structure, too often bear the stamp of lack of permanency, whereas, in point of fact, they ought to be the last parts ever to need repairs. The opinion of General William P. Craighill, Hon. M. Am. Soc. C. E., ex-Chief of Engineers, is well worthy of note in this respect, when, in a report, he stated that a long experience had convinced him that in all construction connected with a lock, especially where the portions would be submerged, nothing but the best and most permanent work was worth putting in. This fact has been long known to European engineers, and

Mr. D. A. Watt.

the use of impermanent materials, such as timber floors, for permanent construction, was long ago discontinued by them. They are well acquainted with the fact that timber, to be permanent under water, must be protected from all currents, or it will be worn away, slowly if exposed to a slight current, and rapidly if exposed to a strong one. It is true that on a lock floor the fibers will be eroded slowly and at a very different rate from the sheathing of a dam, but the effect will be none the less sure, and, as a renewal will mean a stoppage of navigation, pumping out the lock pit, and, in extreme cases, having to build a coffer around the entire lock, the amount saved by a cheap first construction would appear to be a very questionable economy. For a small extra expense, where concrete is available, a solid arched floor could be put in, one that would be free from erosion and free also from that worst of failures in a lock, an upspringing from the pressure below. In the Suresnes lock, just below Paris, completed in 1885, the floor consists of an arch of cut stone, with a rise of 20 ins. in the chamber width of 59 ft., and laid on a bed of masonry several feet thick. This is a most durable method of construction, and, while it may not be followed to the full extent in America, it may be hoped that construction which is impermanent, or economical only in its first cost, will soon become a thing of the past.

As regards the underdraining of a floor, which appears to be a source of anxiety to many engineers, the writer's experience has led him to believe that the only safe way to dispose of the danger from upward pressure is to build the floor strong enough to resist it, and to let the seepage from the upper pool force its way out by making a natural channel of its own. For this purpose there is no section better adapted than the inverted arch, because, for the amount of material, it is by far the strongest type of floor built. The method of providing stone sub-drains seems to be of questionable utility. The rip-rap filling in a crib, in rivers of ordinary sediment, will become completely choked with mud in a single winter, and, as such cribs are usually exposed to more or less current, it would seem reasonable to believe that a sub-drain exposed in time of floods to no passage of water would choke up as readily, and thus defeat its purpose.

The proposed relief by using ball valves, as shown in Fig. 8, while novel and ingenious, is open to objection in that they will render the pumping out of the lock very difficult. Their use is based on the theory that the sheet-piling will prevent seepage from the outside, except to an extent which can be cared for by the pumps. The writer had occasion to pump out a chamber some time ago under a lower-pool head of about 6 ft., the lock in question being on a gravelly foundation, and surrounded by a line of sheet-piling driven as well and as carefully as could have been done in work of this class. The floor was of piles

Mr. D. A. Watt. and double plank, overlaid with concrete. During the repairs, some holes had to be drilled to the plank, and wherever one came in contact with a joint a strong jet of water came up through the hole. Moreover, when pumping was begun (with a 10-in. centrifugal pump), it was found impossible to lower the water more than about 1 ft. Investigation showed that the stone drain usually placed behind a land wall had been arranged to discharge through a 12-in. pipe into the tail-bay, so that it had no communication with the pool when the lower coffer was in, and the water flowing through it must have come under the foundations from outside. The pipe was stopped up with a wooden plug, and the chamber emptied without further difficulty. From such evidence of the passage of water beneath a porous foundation, it would appear reasonable to believe that where openings are made through a floor it will be a matter of considerable difficulty to pump out.

Mr. Wisner. GEORGE Y. WISNER, M. Am. Soc. C. E. (by letter).—The engineering features and details of the lock construction on the Black Warrior, Warrior and Tombigbee Rivers, described by Mr. McCalla, form a valuable contribution to the literature on river improvement in the United States. Like several other large improvement projects now being executed by the General Government, the question of whether the benefits to be derived will warrant the expenditure involved has been given but little consideration, and the probable cost of transportation per ton, as stated, is by no means a fair one for comparison with railroad rates between the same terminals.

An examination of the map of Alabama shows fairly good railroad facilities between the coal fields and the Gulf ports, and the rate quoted, $1.10 per ton for a distance of upwards of 400 miles by water route and 275 miles by rail (about 4 mills per ton-mile by rail, and 2.7 mills per ton-mile for distance by the water route), is certainly not a heavy tax on the development of the mining industries, and is probably as low as the freight can be carried profitably by rail at present, and nearly as low as the rate would be on the completed waterway if all fixed charges, due to construction, maintenance and operation, were included in the rates.

If, in order to promote competition and secure minimum railroad rates from the coal fields of Alabama to the seaboard, the General Government should furnish a right of way, grade the roadbed, lay the rails, and maintain a first-class double-track railroad between the freight terminals at the mines and seaboard, the existing railroads would have just cause of complaint. Yet, to construct and maintain a waterway between the same terminals, free of fixed charges for construction, maintenance and operation, involves exactly the same objections. If the sole object of constructing and maintaining a free waterway is to establish transportation rates, to meet which existing

railroads must be operated at a loss, there are certainly grave doubts whether the work is justified or warranted. Mr. Wisner.

In the writer's opinion, the only conditions which warrant the General Government in constructing a free waterway, between terminals where first-class railroad facilities already exist, is where such waterway will develop new commerce, which otherwise could never be made profitable, and which will indirectly build up new freight traffic of benefit to the railroads as well as to the waterway.

The result of the improvement of the waterways of the Great Lakes is a striking example of building up new commerce which otherwise could not have been established, and which indirectly has resulted in a railroad traffic between the lake ports and the seaboard which has made the railroads, in competition with the lake waterway, the best dividend-paying roads of the country.

The Illinois and Mississippi Canal, from the Mississippi River near Rock Island to Lake Michigan at Chicago, is an equally striking example of useless waste of public money for a waterway which will never develop new commerce to any material extent, nor control the rates on railroads between terminals. Some interesting and instructive engineering work in the way of concrete lock construction has been done on this canal, and, as an example of how to build good concrete locks, the work is of great value to the profession, but, from the point of view of whether it will pay, either directly or indirectly, the project should never have been undertaken.

Under which of these classes of improvements the Alabama work falls is a question which should have been more thoroughly considered by the Government officials than would seem to have been the case.

The author states that "the actual cost of transportation, when the lock system is completed, should not exceed 20 cents per short ton, or ½ mill per ton-mile." This rate does not include anything for interest on the cost of construction, annual expenses for maintenance, repairs and operation, or for profit to the transportation and transfer companies.

The amount by which these fixed charges will increase the transportation rate cannot be stated definitely without a knowledge of the approximate volume of traffic to be expected.

On the Erie Canal, a waterway of approximately the same depth as the one under consideration, the transportation rate averages about 2 mills per ton-mile, and as both are free waterways it is fair to presume that the rates on the Alabama rivers will not be much different from that of the Erie Canal.

On the Chesapeake and Ohio Railroad, it is stated that coal is carried at a profit on a rate of 2¼ mills per ton-mile, and since this rate involves fixed charges for cost of construction and maintenance of the road, it is really comparatively less than the Erie Canal rate.

Mr. Wisner. The Bessemer and Lake Erie Railroad is said to carry ore from Conneaut to Pittsburg at an actual cost, for transportation alone, of 1¼ mills per ton-mile, the actual freight rate being 3.65 mills per ton-mile.

If the business between the coal fields of Alabama and the seaboard will warrant the expenditure of $5 000 000 for a free waterway, there is no reason why a double-track freight railroad, capable of handling coal as cheaply as the Chesapeake and Ohio Railroad, could not be operated at a profit on practically as low a transportation rate as is likely to be charged on the improved waterway, if the fixed charges due to cost, maintenance and operation be included.

In all estimates of transportation rates, it should be noted that there is a vast difference between the actual cost of moving a ton one mile in an open waterway on a loaded vessel, and the rate which must be charged to cover profits, deterioration of works and vessels, repairs, operation, maintenance, fixed charges, and loss from terminal and other detentions. It is extremely doubtful if the boats of the river waterway would be able to go sufficiently near the mines to be loaded without first handling the coal with cars over several miles of railroad, which would involve extensive transfer sheds, and a large addition to the cost of transportation on the waterway, which would be eliminated from the rate if carried on cars direct from the mines to the seaboard.

No data are given in the paper on which estimates for the annual cost of maintenance and operation can be based, but, if the waterway is to be a commercial success when completed, it will be necessary to operate it 24 hours each day. This will require three shifts of men at each lock, and as the rivers are very crooked and narrow—in many places being only 100 ft. wide—a thorough system of lighting for both locks and channel will be necessary.

For the present consideration, the following approximate estimate of the probable annual expense account is based upon a volume of traffic requiring a daily 24 hours' service and the waterway maintained in good condition:

Annual cost of operation and supplies: Twenty locks at $10 000	$200 000
Lighting of locks and channel	50 000
Maintenance of locks and channel	50 000
Extraordinary repairs, supervision and contingencies	50 000
Interest on $5 000 000 at 3%	150 000
Probable annual expenses	$500 000

It is apparent, therefore, that, until the volume of traffic exceeds 1 000 000 tons per year, the cost of transportation due to the necessary fixed charges alone will be 50 cents per ton, or more; to which must be

added a transportation rate of probably 1¼ mills per ton-mile, making the actual cost per ton between terminals practically the same as the present railroad rate. Mr. Wisner.

It is true that with a free waterway the fixed charges, amounting to about one-half the total annual cost of transportation, will be assumed by the General Government, but, as there are no public lands to be developed in the coal regions of Alabama, from which the general public are to receive any returns, it would appear that the only parties to be benefited by the improvement are the owners of the coal and iron mines of Central Alabama. If this is the case it is an open question whether the improvement is of sufficient national importance to warrant the General Government in assuming one-half the cost of transportation of the products from the mines to the seaboard, and whether, if the project is sufficiently meritorious to warrant the expenditure, it would not be more just to the people of the entire country to charge sufficient toll to make the enterprise self-supporting, and thereby place the annual expenses on the property and business to be benefited.

It is not the writer's purpose to question the advisability of the project, which, from the data available in the reports of the Chief of Engineers, cannot be stated definitely, but to raise the issue as to who should pay for and maintain improvements of waterways and harbors where the benefits are purely local and have no direct bearing on the commerce of the whole country. The large number of projects provided for in the River and Harbor Bill of 1901 which were open to this criticism caused its failure to pass Congress, and the bill which recently became a law narrowly escaped the same fate, for similar reasons.

There is a tendency on the part of legislators to scrutinize this class of expenditures more closely than heretofore, and engineers having charge of projects requiring national support will have to show wherein the commerce of the country will be either directly or indirectly benefited, or the necessary appropriations will not be obtained easily in the future.

John M. G. Watt, M. Am. Soc. C. E. (by letter).—The problems involved in the design of a lock to be constructed on the solid rock are neither difficult nor unusual, being simply those of a retaining wall, or of a wall to resist hydrostatic pressure, combined, in certain parts, with the thrust from the gates. The chief points to be considered are the details, principally those of the filling and emptying valves and the machinery of the lock. If, however, the foundations are not on such favorable material, complications set in, and these must be provided for as each particular case may demand. The writer does not propose to discuss the general principles of lock design, but to call attention to some details which have proved useful in his experience. Mr. J. M. G. Watt.

The guard of a lock with a fixed dam, or the height of its top above

Mr. J. M. G. Watt.

the dam crest, must be determined in accordance with the varying conditions. Theoretically, it should be such that navigation over the dam can be had from the moment when the lock passes out of use through submergence. Practically, other conditions may determine this. To illustrate: At Lock No. 8, on the Kentucky River, where the guard is 10 ft., the fall over the dam, when the lock passes out of use, is from 7 to 9 ft., consequently there can be no passage either through the lock or over the dam. To render the lock navigable until the river rises to such a height as to obliterate this fall, the walls would need to be raised about 5 ft., necessitating a comparatively large outlay for the incommensurate result of a few extra days of navigation each year; but, at this stage of the river, the current is very swift, and very heavy drift is generally running; besides this, many of the regular landings are submerged, and passage under some of the bridges over the river is impossible; therefore navigation is suspended until the rise has partially subsided. In view of this condition it would not have been economy to make the guard 15 ft., and it was therefore made such that the lock could be used up to the stage when boats generally stopped running.

For filling and emptying the lock, in the writer's opinion, culverts in the walls, passing around the hollow quoin, are the best. Valves in the gates are a possible source of weakness, and, whether opened with worm-gear or with rack and quadrant, all offer the objection that they have to be maneuvered on the narrow width of the gate, in all sorts of weather and temperature, and both day and night, being especially dangerous when the gates are coated with snow or sleet. Culverts in the walls may be closed with butterfly valves on a vertical axis, or with cylindrical valves. If the former, the frames in which they fit should be of metal, not of wood, and should be cemented watertight when set. Those with which the writer has had to do are made, some of cast iron, others of wrought plates, channels and angles, all with unequal arms, and opening with the longer arm inward and up stream; these arms are designed so that, when the valve is closed, the longer arm has less of its surface exposed to the water pressure than the shorter, and, consequently, the excess of pressure keeps the valve closed. Cylindrical, cast-iron valves are in use upon the Muskingum River, and have given satisfaction; they will be used in Locks Nos. 1 and 2, on the Big Sandy River, Locks Nos. 9 and 10, on the Kentucky River, and in the proposed lock at Colbert Shoals, in the Tennessee River. They have the advantage of simplicity and of ease in operation, and are set farther back from the face of the wall than the butterfly valves, thus giving the lockmen greater safety when operating in icy weather.

For opening and closing the gates by hand power; the writer, after much investigation, has found nothing entirely satisfactory, but the best, in his opinion, is the steel rack-bar, built up of two channels,

latticed, with cast-iron rack, attached to the top of the gate at about one-third the distance from the miter post, or less. This rack is operated by a gear wheel on which is a capstan head with sockets for bars, and which can be set back far enough on the wall to ensure safety to the men if they should slip when nearest to the lock pit. For the river walls, this rack should be supported, when the gate is open, on a bracket on the outside of the wall, removable in times of flood. Mr. J. M. G. Watt.

For coffering the upper and lower bays, in order to make repairs in the chamber, permanent trestles to support needles have been used. The writer considers these objectionable, for two reasons: First, the danger of deterioration by rust. These trestles are constantly under water, and inspection cannot be had, nor can they be repainted without removal by a diver, or unless the pool is drawn, or another coffer put in, suspending navigation for the time; consequently, when the time comes to use the trestles, they may prove unreliable because of loss of strength by rust. The other reason is that they are in the way of dredging. Trestles were put in the upper entrance to Lock No. 6, on the Kentucky River, when built in 1891, but there has never yet been occasion to use them. Dredging is necessary there every year after the winter and spring rises, and great care is exercised by the dredge runner at that spot, yet, in spite of this care, the trestles are struck more or less often by the dredge dipper, and one was caught so badly that it was torn out; whether the others are in a fit state to use, or whether they are bent or distorted, is not known. For locks having a width of not more than 52 ft. in the chamber, timber beams can be built up to span the opening, letting the needles rest against them and against a shoulder made for that purpose on the lock floor. For larger spans it would be desirable to use a removable steel truss above the water level, supported on temporary timbers, or removable trestles, both with steel needles formed of I-beams and buckle plates, from 2 to 4 ft. wide, or with ordinary timber needles. The journals for these trestles would be set permanently, and would be made extra heavy to resist rust. The trestles would be 10 ft. apart, and it would take but a short while to set them and their needles in place. After use they would be removed, cleaned and taken to their place of storage, where they could always be inspected and kept in good condition.

The question of whether a fixed or a movable dam should be used, is one that must be decided by the requirements of the commerce of the river under consideration.

For a fixed dam, the experience of the writer has led him strongly to prefer a concrete to a timber structure, as being more economical, and less a cause of worry. Timber is supposed to last indefinitely under water, and, as a general rule, it does, but it is just the exceptions that cause all the trouble, and the writer has been compelled to tear out many thousands of feet of good timber in order to get down

Mr. J. M. G. Watt. deep enough to that which had rotted and was causing the overturning of the structure. When the cost of this demolition and reconstruction is taken into account, it will be found that concrete is just as cheap. If concrete is used, the down-stream slope of the dam should not be steeper than 45°, and it should terminate in an apron with a flat curve upward. This apron should be as long as possible, in order to give a good discharge to the water. See Fig. 31.

If a dam of timber cribs filled with stone is used, it can, unless the river is a very swift one, be built along the shore, in quiet water, for several courses, and then be towed to position, sunk and filled. The bottom course of timber should be blocked up so as to fit the bed of

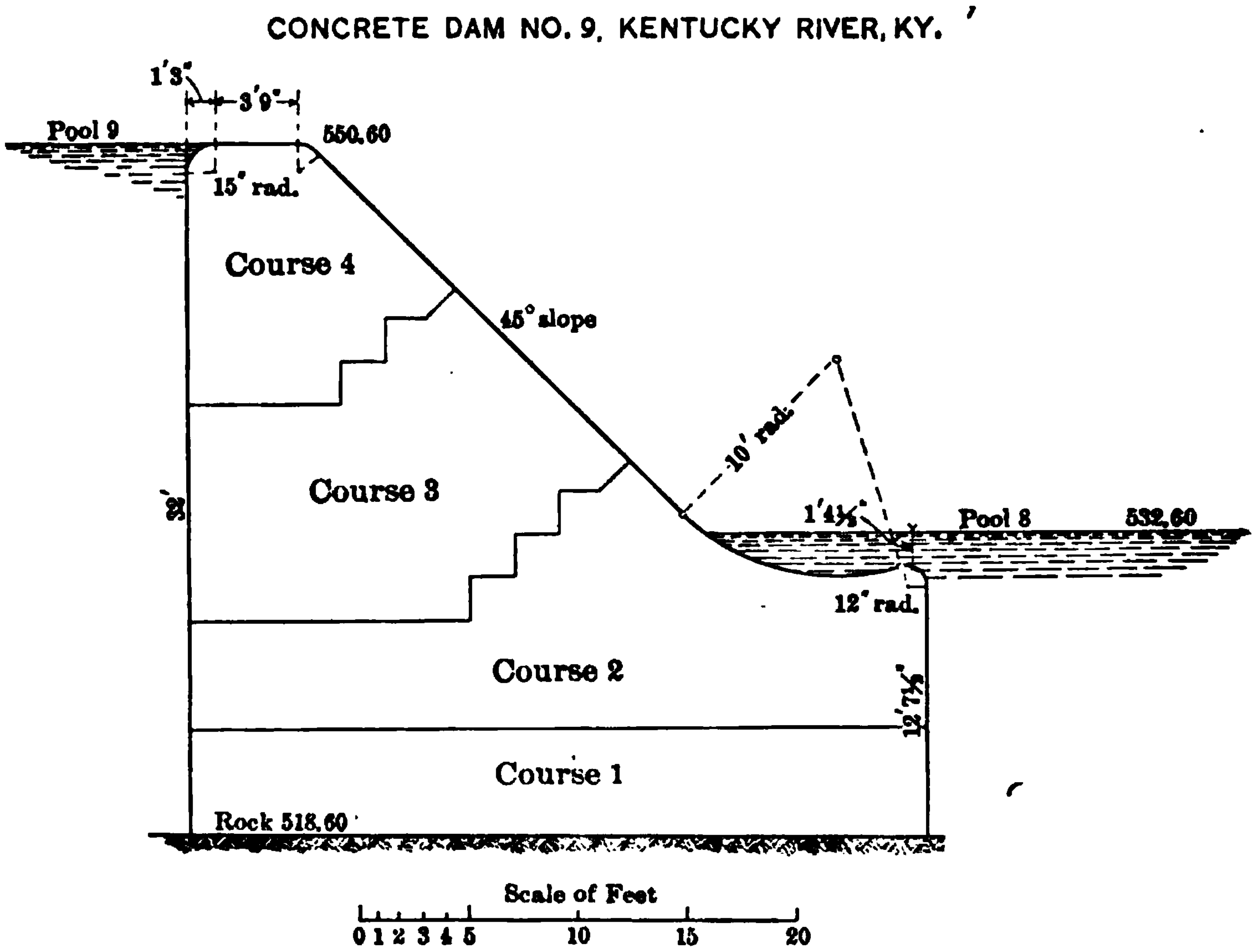

Fig. 31.

the river, approximately, according to soundings taken before building; this has been carried out successfully by the writer with cribs 250 ft. long, 50 ft. wide and 8 to 10 ft. high, with very little trouble. This method has the advantage of leaving the river open until the last moment. This kind of dam is dependent only upon its weight, the timber cribs being simply so many boxes to prevent the stone from being washed away, and all dapping of cross-timbers and splicing of longitudinal timbers is an unnecessary expense. It has been the writer's practice to use butt joints everywhere. In the face of the work the butt joints of the stringers come over a tie, in the interior they may come over a tie or anywhere between two ties; the result has been quite satisfactory and cheap. The use of timbers square in

cross-section, and not simply oblong, is also advisable for economy. Any side may then be put uppermost, and no time is wasted in making extra turns. This item is small, but is worth consideration. The most economical size of timber on the work on the Kentucky River has proved to be 10 x 10 ins., this being more easily obtained than 12 x 12 ins., and being amply large. The pens of dams and cribs are all 10 ft. from center to center each way. The sheathing on the up-stream side of the dams is formed of one layer of 3-in. plank, covered by 2-in. plank, breaking joints. These can be laid close enough to obviate any necessity for caulking, but should any joints open they will soon be filled with deposit. The top layer of the sheathing is in two lengths, the one next the crest being short, as it can then be removed easily when worn out, and replaced without drawing the pool down more than 12 or 15 ins. Probably a still better way to construct the crest would be to stop the sheathing 12 ins. from the crest, and fill this space with longitudinal 12-in. plank. This would entail less labor and time in tearing up when worn out. Mr. J. M. G. Watt.

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AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

RELATIVE PERMANENCE OF STEEL AND MASONRY CONSTRUCTION.

An Informal Discussion at the Annual Convention, May 21st, 1902.*

SUBJECT FOR DISCUSSION.

"Is steel susceptible of being made as permanent a building material as masonry?"

By JOHN F. O'ROURKE, M. Am. Soc. C. E.

Mr. O'Rourke. J. F. O'ROURKE, M. Am. Soc. C. E.—Perhaps the principal feature in relation to the durability of steel is the effect of water upon steel in structures. If steel or metal is exposed to the combined action of air and water a condition is brought about that soon produces rust, which is simply the decomposition of the metal. One of the most illuminating examples of the effect of water on metal, with and without air, was brought to the speaker's notice about three years ago. Willson, Adams & Co., lumber dealers on the Harlem River, had put in an artesian well, hoping to get water to take the place of the Croton supply. The water obtained was brackish, but much cooler than the Croton water in summer. It was not fit to drink, but, in order to take advantage of its temperature, they made a U of ⅜-in. pipe, carrying it down about 100 ft. into the well and putting a faucet on its return end. In this way they obtained a pleasant temperature for drinking water all the year round. This pipe was retained in place

*The discussion of this subject, on which no formal paper was presented, is continued from the August, 1902, *Proceedings*.

for, perhaps, ten years. At the end of that time it had rusted off and had to be taken out. The part of this pipe above the water was found to be absolutely rotten. The pipe which had been below the water was in perfect condition, and even retained the blue mill scale and tool marks. Upon this part of the pipe, however, there was a whitish coating, like thin whitewash, which could be rubbed off with the fingers. Whether this coating preserved the metal from oxidation, or whether it was the fact that metal does not become oxidized in water alone, are matters for future discussion. The fact is, the metal which had been below water did not show the least sign of decomposition of any kind. Mr. O'Rourke.

A short distance below the yard of Willson, Adams & Co., the old bridge which crossed the Harlem River at Third Avenue had been supported on pneumatic piles—the speaker thinks they were among the first that were put down in this country. These piles were of cast iron, 6 to 8 ft. in diameter, with interior flanges and bolts to connect them. These bolts were put in in the usual way; and the piles, after being sunk to place, were filled with concrete. The joints were not water-tight; they never are; so everything was immersed, being below the river surface. After 35 or 40 years, when these piles were removed, at the time of building the present structure, the bolts in the flanges were found to be perfectly free from rust. Not only that, they were greasy; the oil on the bolts was there, apparently in the same condition as when put in years before.

The speaker has never known a case where steel or iron corroded when kept away from the influence of the air. He has no hesitation whatever in using steel in connection with structures where there is clean water, if the water remains at a constant level; no more than he has in using wood under similar conditions.

At the present day everybody wants structures built of what might be called high-power material. High power material, in the speaker's opinion, not only possesses high power, but high durability to the same extent, and it only requires care to keep it properly protected against rust. The speaker would use steel or iron under the same conditions that he would use wood.

The durability of pipes is greater when there are inorganic or mineral impurities in the water, than when the water contains organic impurities, as Mr. Darrach has intimated.

The speaker has known of cases, and there are cases on record in the *Transactions* of this Society, where piles which were constantly submerged have rotted, simply because they were exposed to the action of sewage; or, in other words, because they came in contact with organic impurities. Organic impurities act on steel or wood just as a salicylic acid bath would act on masonry. No one will contend that any material is indestructible when in contact with sub-

Mr. O'Rourke. stances which will break it up. Organic impurities will destroy anything. They cause loss of materials and loss of life. Man cannot stand them, nor can iron. Inorganic impurities, or the clean chemical agents, under certain conditions, will act in a manner that can be foreseen, but with the many organic impurities, few of which are sufficiently known, there is too much uncertainty. When they exist, metal, however protected, should not be risked.

MEMOIRS OF DECEASED MEMBERS.

NOTE.—Memoirs will be reproduced in the Volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors. should be forwarded to the Secretary prior to the final Publication.

IRA ALEXANDER SHALER, M. Am. Soc. C. E.*

DIED JUNE 29TH, 1902.

Ira Alexander Shaler was born in Ridgefield, New Jersey, on September 19th, 1862. He was the son of General Alexander Shaler, who served in the Army of the Potomac with distinction. His mother, before marriage, was Miss Mary McMurray, of New York City. Major Shaler was a direct descendant, in the eighth generation, of Captain Thomas Shaler, who came to America from Stratford on Avon, England, in 1662, and, with twenty-seven other emigrants, founded the town of Hadden, in Connecticut, where most of his descendants lie buried.

At the age of eight young Shaler was sent to a private school in New York. Three years later he entered the Public Grammar School No. 55, from which he was graduated in 1878. For the next two years he studied at the College of the City of New York, and in all these schools his record was excellent.

On September 16th, 1880, he entered Cornell University as a sophomore, taking for the first year the general course of Science and Letters. Feeling, however, that this led to no particular profession, and desiring to work for some specific purpose, he decided to take the course of Civil Engineering. He was graduated, with the degree B. C. E., in 1884. Two years later he received his M. C. E. from Cornell University.

Soon after graduation he entered the Engineer Corps of the Aqueduct Commissioners of the City of New York, being first engaged in the office of the Chief Engineer, and, later, in the field, on the construction of the New Croton Aqueduct. As Assistant Engineer he had charge of a section of the Aqueduct Tunnel on Manhattan Island, of the 135th-Street Gate House, and of the pipe line from 135th to 125th Streets.

His tastes, however, were more in the line of contracting than of engineering, and, therefore, he left the service of the Aqueduct Commissioners in 1889 to engage in contracting. Among the works executed by him, either alone or in partnership with others, were the Cornell Hydraulic Laboratory; the Titicus Dam, forming a reservoir

* Memoir prepared by Edward Wegmann, M. Am. Soc. C. E.

for New York City; the United States fortifications on Gull Island; the Cold Spring (N. Y.) Dam; the water-works for Gloversville, New York, and the changing of the Madison Avenue car tracks to a conduit electric system.

At the beginning of the Spanish War, Major Shaler offered his services to the Governor of New York to raise an engineer regiment to serve during the war, but, learning that the Governor had no authority to furnish such a regiment, he accepted an invitation from Colonel Eugene Griffin to assist him in organizing the First Regiment, U. S. Volunteer Engineers, and was appointed Captain of Company F. He accompanied this Regiment to Puerto Rico, and returned with it as Major of the Second Battalion.

In January, 1899, Major Shaler was married to Miss Mary Duncan Leverich. After spending a year abroad with his wife, he returned to New York to engage again in contracting, and obtained a sub-contract for Section 4 of the New York Rapid Transit Road. This section, which is entirely in tunnel, extends under Fourth Avenue from 34th to 42d Streets. On this work Major Shaler met with a series of almost unparalleled misfortunes. On January 27th, 1902, his supply of dynamite exploded, killing five persons and doing great damage to the Murray Hill Hotel and other buildings. While Major Shaler was exonerated from all blame in this matter, he was responsible for the damage done. This explosion ruined him, financially.

On February 22d occurred the conflagration of the 71st Regiment Armory at 34th Street and Fourth Avenue, which burned a part of Major Shaler's plant and tools. On March 21st some ledges of rock slid into the tunnel, causing such damage to four houses opposite that they had to be purchased by the contractor to avoid suits for damages. This series of disasters culminated on June 17th, when Major Shaler was inspecting his tunnel with Chief Engineer William Barclay Parsons and Deputy Chief Engineer George S. Rice. A mass of rock became detached from the roof and struck Major Shaler on the back of his head and shoulders, causing injuries of which he died on June 29th, 1902.

Major Shaler had a force of character that inspired with confidence all who came in contact with him. His mind was well balanced. In prosperity, as in adversity, he remained the same. He had a cheerful disposition, was very energetic, a disciplinarian, and yet so just that he was liked by those who worked under him. By nature cautious, he would discard defective machinery long before it was worn out. He was very conscientious, and followed what he conceived to be his duty even though it involved a loss. At the outbreak of the Spanish War, though engaged to be married, nothing could deter him from performing what he conceived to be his duty, viz., to offer his services to his country.

His manly character, genial disposition and many other sterling qualities won him a host of friends. His unselfish nature was well shown by the first words he uttered after being stricken down by the heavy piece of rock that broke his back and inflicted other serious injuries. These words were:

"I am afraid that my back is broken, for I have no feeling in my body. Take me to the hospital, so that Mrs. Shaler won't see me until she has been warned. Break the news to her just as gently as you can, then bring her to me. Bring, also, my father and mother. Let the work on this section go right on."

Major Shaler was a member of the Alpha Delta Phi, Barnard and Cornell Clubs, and a member of the Loyal Legion (second class). He was elected a Junior of the American Society of Civil Engineers on July 4th, 1888, and a Member on June 5th, 1895.

American Society of Civil Engineers.

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ON RAIL SECTIONS:—G. Bouscaren, C. W. Buchholz, S. M. Felton, Robert W. Hunt, John D. Isaacs, Richard Montfort, H. G. Prout, Joseph T. Richards, Percival Roberts, Jr., George E. Thackray, Edmund K. Turner, William R. Webster.

The House of the Society is open from 9 A.M. to 10 P.M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

HOUSE OF THE SOCIETY—220 WEST FIFTY-SEVENTH STREET, NEW YORK.

TELEPHONE NUMBER, - - - - 588 Columbus
CABLE ADDRESS, - - - - - "Ceas, New York."

Vol. XXVIII. OCTOBER, 1902. No. 8.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PROCEEDINGS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

SOCIETY AFFAIRS.

CONTENTS:

MINUTES OF MEETINGS.

OF THE SOCIETY.

October 1st, 1902.—The meeting was called to order at 8.40 P. M., Joseph M. Knap, Treasurer, Am. Soc. C. E., in the chair; Assistant Secretary T. J. McMinn acting as Secretary; and present, also, 76 members and 7 visitors.

The minutes of the meetings of September 3d and 17th, 1902, were approved as printed in *Proceedings* for September, 1902.

A paper by Theron A. Noble, M. Am. Soc. C. E., entitled "The Flow of Water in Wood Pipes," was presented by the Acting Secretary, who also read communications on the subject from Messrs. Ernest W. Schoder and A. V. Saph. The paper was discussed orally by Messrs. Gardner S. Williams and Rudolph Hering.

Ballots for membership were canvassed, and the following candidates were elected:

As Members.

Percy Allan, Sydney, N. S. W., Australia.
George Joseph Bell, Carlisle, England.
George Holland Binkley, Chicago, Ill.
George Bowers, Lowell, Mass.
Francis Elihu Crane, Amsterdam, N. Y.
Harvey Farrington, Croton-on-Hudson, N. Y.
Julian Way Kendrick, Birmingham, Ala.
Charles Henry Kluegel, Honolulu, Hawaiian Islands.
Thomas Hoggan Mather, Syracuse, N. Y.
Frank Berry Sanborn, Tufts College, Mass.
Frederick Eduard Schall, South Bethlehem, Pa.
George Washington Sublette, Minneapolis, Minn.
Fred Thompson, Norfolk, Va.
Charles Hunter West, Greenville, Miss.
Roscoe Cyprian Young, Iowa Falls, Iowa.

As Associate Members.

Ralph Albree, Allegheny, Pa.
Richard William Carter, Leavenworth, Kans.
Alger Adams Conger, Sault Ste. Marie, Mich.
Dudley Tibbits Corning, Tomhannock, N. Y.
Washington Righter Craig, St. Marys, Pa.
Frank Oliver Dufour, Cincinnati, Ohio.
George Harrison Fenkell, Erie, Pa.
Frederick Luther Ford, Hartford, Conn.
Ray Elliott Griswold, Port of Spain, Trinidad, B. W. I.
Louis Wells Hall, Tuscaloosa, Ala.
Frederick Eugene Lane, Brooklyn, N. Y.
Norman Banks Livermore, San Francisco, Cal.
Don Alexander MacCrea, Guthrie, Okla. T.
Lewis Henry Mattair, Matanzas, Cuba.
Henry Francis Nichols, Adelaide, South Australia.
Edmund Payton Ramsey, Brooklyn, N. Y.
Carl Louis Eduard Schenk, Walkers Mills, Pa.
William Frederick Steffens, New York City.
Warren Ayres Tyrrell, St. Louis, Mo.

The Acting Secretary read the list of nominees* presented by the Nominating Committee for the offices to be filled at the next Annual Meeting, January 21st, 1903.

* See page 292.

The Acting Secretary announced the death of CHARLES HAZLEHURST LATROBE; elected Member, November 16th, 1870; died September 19th, 1902.

Adjourned.

October 15th, 1902.—The meeting was called to order at 8.40 P. M., Emil Kuichling, Director, Am. Soc. C. E., in the chair; Chas. Warren Hunt, Secretary; and present, also, 83 members and 15 guests.

A paper, entitled "The Protection and Improvement of Foreshores by the Utilization of Tidal and Wave Action," by R. G. Allanson-Winn, M. Inst. C. E. I., was presented by the Secretary, who also read communications on the subject from L. M. Haupt, M. Am. Soc. C. E., and the author.

The paper was discussed orally by Messrs. Rudolph Hering and E. B. Thomson.

The Secretary announced the election of the following candidates by the Board of Direction on October 7th, 1902:

AS ASSOCIATE.

MERRILL WATSON, New York City.

AS JUNIORS.

EDWARD MAGUIRE ADAMS, Washington, D. C.
ALEXANDER FLOYD ARMSTRONG, Ogdensburg, N. Y.
HAROLD JAMES MANNING BAKER, Port Townsend, Wash.
HOWARD EDWARD BOARDMAN, New York City.
OLIVER CROMWELL EDWARDS, Jr., Steubenville, Ohio.
JOHN WARREN DUBOIS GOULD, Yonkers, N. Y.
LEWIS TUSTLER HANEY, St. Elmo, Va.
EDWARD CRESWELL HEALD, Phœnixville, Pa.
STIRLING BRYANT HILL, Ithaca, N. Y.
ALEXANDER RIEMAN HOLLIDAY, New Castle, Pa.
SHIRLEY CLARKE HULSE, Ithaca, N. Y.
RALPH CHARLES KIMBALL, Evart, Mich.
KIEFFER LINDSEY, Columbus, Ga.
HARRY PEAKE McDONALD, Jr., Jersey City, N. J.
JOHN HENRY MADDEN, New York City.
DAVID HEYDORN RAY, New York City.
RALPH HARVEY SABIN, Sherman, Tex.
CHARLES HERMAN SNYDER, Johnstown, Pa.
WILLIAM PURVES TAYLOR, Philadelphia, Pa.

Adjourned.

OF THE BOARD OF DIRECTION.

(Abstract.)

September 2d, 1902.—Vice-President Schneider in the chair; T. J. McMinn acting as Secretary; and present, also, Messrs. Briggs, Osborn, Pegram and Seaman.

Reconsideration ballots were canvassed, and Marc Otto Eidlitz and Hans August Evald Conrad von Schon were declared elected Members of the Society, and George Corrie Bartram was declared elected an Associate Member of the Society.

Applications were considered and other routine business transacted.

Seven candidates for Junior were elected.*

Adjourned.

October 7th, 1902.—Vice-President Haines in the chair; Chas. Warren Hunt, Secretary; and present, also, Messrs. Croes, Frazier, Jackson, O'Rourke, Osborn, Schneider, Seaman, Van Hoesen and Wilgus.

The time and place for holding the next Annual Convention was considered, and the Chairman authorized to appoint a Committee to report to the Board on the matter.

A proposed change in the form of ballots for the election of members was considered.

The appointment of the following Committee, to award prizes for the year ending with the *Transactions* for July, 1902, was announced: H. M. Chittenden, Bernard R. Green, L. F. G. Bouscaren.

Notice was received from the Executor of the will of the late Herbert Steward, Assoc. Am. Soc. C. E., that he was prepared to pay Mr. Steward's bequest to the Society. The extract from Mr. Steward's will, making this bequest, is as follows:

"I give and bequeath to the American Society of Civil Engineers the sum of two thousand dollars, to be known as the Herbert Steward Library Fund. The fund shall be invested and utilized as the Board of Direction of said Society may elect, provided it shall secure a yearly income; which income shall be entirely expended each year for the purchase of books, maps, or apparatus suitable for the Library of said Society, or for the purpose of promulgating engineering information. I also give to said Society such technical books from my library as may be selected by the Secretary of the Society."

The proper steps were taken to accept the legacy under the terms of the will.

A special subscription of £10 to the Library Fund of the Society from *Sir* Benjamin Baker, Hon. M. Am. Soc. C. E., was received, and acknowledged with thanks.

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* See page 265, September, 1902, *Proceedings*.

The following resignation was received and accepted: Harry Alexander Gillis, Assoc. M. Am. Soc. C. E.

Applications were considered and other routine business transacted.

One candidate for Associate and nineteen for Junior were elected.*

Adjourned.

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* See page 289.

ANNOUNCEMENTS.

The House of the Society is open from 9 A. M. to 10 P. M every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

LIST OF NOMINEES FOR THE OFFICES TO BE FILLED AT THE ANNUAL MEETING, JANUARY 21st, 1903.

The following list of nominees for the offices to be filled at the Annual Meeting, January 21st, 1903, received from the Nominating Committee, was presented to the Board of Direction at its meeting on June 3d, 1902, and announced at the meeting of the Society on October 1st, 1902. The list has already been mailed to all Corporate Members:

For President, to serve one year.

Alfred Noble, New York City.

For Vice-Presidents, to serve two years.

James D. Schuyler, Los Angeles, Cal.
L. F. G. Bouscaren, Cincinnati, Ohio.

For Treasurer, to serve one year.

Joseph M. Knap, New York City.

For Directors, to serve three years.

Joseph O. Osgood, Plainfield, N. J., representing District No. 1.
Alfred Craven, Yonkers, N. Y., representing District No. 1.
George S. Davison, Pittsburg, Pa., representing District No. 4.
Hunter McDonald, Nashville, Tenn., representing District No. 6.
E. C. Lewis, Nashville, Tenn., representing District No. 6,
Elwood Mead, Cheyenne, Wyo., representing District No. 7.

PROPOSED AMENDMENT TO THE CONSTITUTION.

The following proposed amendment to the Constitution has been received by the Secretary, and has been sent to all Corporate Members of the Society. In accordance with the provisions of Section 2 of Article IX of said Constitution, it will be considered at the Annual Meeting, January 21st, 1903:

Amend Article III of the Constitution as follows:

Section 2, first line, after the words "Society as" strike out the words "Member or as Associate" and insert the words "a Corporate"; second line, after the word "to" strike out the words "either grade of."

Section 2, Art. III, will then read, "An application for admission to the Society as a Corporate Member, or for transfer from any other grade to Corporate Membership shall embody," the rest of the section standing as now.

Section 3, third line, after the word "membership" strike out the words "in any grade," and after the word "transfer" strike out the words "from one grade to another"; twelfth line, for the word "may" substitute the word "shall." The section will then read as follows:

"At stated periods, to be determined by the Board of Direction, there shall be issued to each member in any grade whose address is known, a list of all new applications received for membership or for transfer, which list shall be dated and shall contain a concise statement of the record of each applicant and the names of the references in the case of Corporate Member, and endorsers in the case of Associate, Junior or Fellow, with a request that members transmit to the Board any information in their possession which may affect the disposition of the applications. Not less than twenty days after the issue of such list, the Board of Direction shall consider these applications, together with any information in regard to the applicants that may have been received; may make further inquiries, if deemed expedient; shall classify the applicant with his consent, and on applications for Corporate Membership may direct a ballot."

Proposed by
H. G. PROUT,
G. S. WILLIAMS,
ALF. P. BOLLER,
GEO. Y. WISNER,
GEO. F. SWAIN.

MEETINGS.

Wednesday, November 5th, 1902.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and a paper by Isaac Harby, Jun. Am. Soc. C. E., entitled "The Footbridge for Building the Cables of The New East River Bridge," will be presented for discussion.

This paper was printed in the *Proceedings* for September, 1902.

Wednesday, November 19th, 1902.—8.30 P. M.—At this meeting a paper by J. Francis Le Baron, M. Am. Soc. C. E., entitled "An Alternative Line for the Nicaragua Canal, and a Proposed New Method of Dam Construction," will be presented for discussion.

This paper is printed in this number of *Proceedings*.

ACCESSIONS TO THE LIBRARY.

From September 10th to October 7th, 1902.

DONATIONS.*

LE CANAL DE SUEZ.

Par Voisin Bey. Paper, 9 x 6 ins., 3 vol. and Atlas. Paris, Ch. Dunod, 1902.

The Contents are: Historique Administratif et Actes Constitutifs de la Compagnie—Période des Études et de la Construction, 1854 à 1869; Période de l'Exploitation, 1° de 1870 à 1882; Période de l'Exploitation, 2° de 1883 à 1902.

CAMBRIA STEEL.

A Handbook of Information Relating to Structural Steel Manufactured by the Cambria Steel Co., Containing Useful Tables, Rules, Data and Formulæ for the Use of Engineers, Architects, Builders and Mechanics. Leather, 7 x 4½ ins., 10 + 428 pp., illus. Philadelphia, Cambria Steel Co., 1901. $1.00.

The preface states that the present edition contains all the data of the preceding one, which, however, has been corrected where necessary and revised to conform to the present practice of the Company. A large amount of new matter has been added, including drawings of new sections of T-bars, special channels and special angles, with tables of weights, dimensions and properties therefor. Other new matter has also been introduced, the principal items of which are as follows: Drawings and tables relating to new standard connection-angles for beams and channels, giving location and other data for sections of different depths framing opposite each other; tables of safe loads for beam columns, latticed channel columns, plate and channel columns, plate girders and beam box-girders; also tables of dimensions of Z-bar columns, latticed channel columns and plate and channel columns. There is an index of eleven pages.

LES GAZOGÈNES.

Par Jules Deschamps. Paper, 10 x 6½ ins., 436 pp., illus. Paris, Ch. Dunod, 1902. 15 fr.

The Contents are: La définition, l'utilité et la variété des gazogènes; La combustion; Les combustibles; La gazéification des combustibles; Le pouvoir calorifique; Les appareils de distillation; Les gazogènes dits de gaz à l'eau; Les gazogènes Siemens; Les gazogènes Dowson; Les gazogènes à combustion renversée; Les gazogènes à deux cuves; Les gazogènes spéciaux; Les appareils auxiliaires; Récupérateurs et régénérateurs; Application des gazogènes à la production de la force motrice.

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* Unless otherwise specified, books in this list have been donated to the Library by the Publisher.

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U. S. Patent Office. 1 vol.
U. S. War Dept. 1 bound vol., 10 vol.
Univ. of Ill. Agricultural Exper. Station. 1 pam.

BY PURCHASE.

Weser und Ems, ihre Stromgebiete und ihre wichtigsten Nebenflüsse. Eine hydrographische, wasserwirthschaftliche und wasserrechtliche Darstellung. Auf Grund des Allerhöchsten Erlasses vom 28. Februar, 1892, im Auftrage des preussischen Wasser-Ausschusses herausgegeben von H. Keller. 5 vols. and Atlas. Berlin, Dietrich Reimer, 1901.

SUMMARY OF ACCESSIONS.

From September 10th to October 7th, 1902.

Donations (including 12 duplicates)	203
By Purchase	6
Total	209

MEMBERSHIP.

ADDITIONS.

MEMBERS.

		Date of Membership.
BOWERS, GEORGE		
City Engr., 359 Westford St., Lowell, Mass.		Oct. 1, 1902
COHEN, FREDERICK WILLIAM		
Engr. of Erection, Bridge and Constr. Dept.,	Assoc. M.	Feb. 3, 1897
The Pennsylvania Steel Co., Steelton, Pa.	M.	Sept. 3, 1902
CRANE, FRANCIS ELIHU		
City Engr., Amsterdam, N. Y.		Oct. 1, 1902
ELDRIDGE, GRIFFITH MORGAN	Assoc. M.	June 1, 1892
Mgr., Eldridge Drug Stores, Americus, Ga.	M.	Sept. 3, 1902
FARRINGTON, HARVEY	Jun.	June 19, 1891
Cons. Engr., 115 Broadway, New York	Assoc. M.	Feb. 6, 1895
City	M.	Oct. 1, 1902
McDONALD, WILLIAM NAYLOR		
Supt. of Streets and Parks, Tacon St. No. 3, Havana, Cuba		Sept. 3, 1902
YOUNG, ROSCOE CYPRIAN		
Chf. Engr., Des Moines, Iowa Falls & Northern Ry., Iowa Falls, Ia.		Oct. 1, 1902

ASSOCIATE MEMBERS.

ALBREE, RALPH		
1115 Market St. (Res., 1112 Western Ave.),	Jun.	Oct. 4, 1898
Allegheny, Pa.	Assoc. M.	Oct. 1, 1902
ASHBRIDGE, RICHARD I. DOWNING		
Room 710, City Hall, Philadelphia (Res., East Downington, Chester Co.), Pa.		Sept. 3, 1902
CARTER, RICHARD WILLIAM		
Asst. Engr., Mo. Valley Bridge & Iron Works (Res., 1000 South 4th St.), Leavenworth, Kans.		Oct. 1, 1902
CONGER, ALGER ADAMS		
Asst. Engr., Michigan Lake Superior Power Co., Sault Ste. Marie, Mich.		Oct. 1, 1902
CORNING, DUDLEY TIBBITS		
Asst. Engr., Troy Water-Works Extension, Tomhannock, N. Y.		Oct. 1, 1902
CRAIG, WASHINGTON RIGHTER		
Res. Engr., P., S. & N. R. R. Co., Bolivar,	Jun.	May 1, 1894
N. Y.	Assoc. M.	Oct. 1, 1902
LANE, FREDERICK EUGENE		
Res. Engr., Div. 4, Atlantic Ave. Impvt., L. I. R. R., 5 Hanson Pl. (Res., 1037 Bergen St.), Brooklyn, N. Y.		Oct. 1, 1902

		Date of Membership.
Mac Crea, Don Alexander		
Div. Engr., C., O. & G. R. R., Guthrie, Okla. T.	Jun. / Assoc. M.	May 2, 1899 / Oct. 1, 1902
Pettee, Eugene Everett		
269 Lowell Ave., Newtonville, Mass		Sept. 3, 1902
Rickey, James Walter		
508 South First St., Minneapolis, Minn		Sept. 3, 1902
Roberts, George Thomas		
Asst. Engr., Bureau of Eng., 13 City Hall (Res., 941 Elk St.), Buffalo, N. Y.		Sept. 3, 1902
Sanders, Francis Nicoll		
235 State St., Albany, N. Y		Sept. 3, 1902
Schenk, Carl Louis Eduard		
Box 82, Walkers Mills, Pa		Oct. 1, 1902
Turneaure, Frederick Eugene		
Prof. of Bridge and San. Eng., Univ. of Wis., Madison, Wis	Assoc. / Assoc. M.	Aug. 31, 1897 / June 4, 1902
Tyrrell, Warren Ayres		
Care, Maule, Hannah & Co., 1416 Chemical Bldg., St. Louis, Mo	Jun. / Assoc. M.	Oct. 2, 1900 / Oct. 1, 1902
Wiggin, Ernest Woodbury		
Asst. Bridge Engr., N. Y., N. H. & H. R. R., New Haven, Conn	Jun. / Assoc. M.	May 5, 1896 / May 7, 1902
Wright, Moses Hannibal		
Roadmaster, L. & N. R. R., Nashville, Tenn	Jun. / Assoc. M.	Jan. 2, 1900 / Sept. 3, 1902

ASSOCIATE.

Stearns, Fred Lincoln	
52 West 126th St., New York City	June 3, 1902
Watson, Merrill	
Mgr. and Treas., The N. Y. Expanded Metal Co., 256 Broadway, New York City	Oct. 7, 1902

JUNIORS.

Getchell, William Stewart	
Care, W. M. Porter, Asst. Chf. Engr., Colo. Fuel & Iron Co., Denver, Colo	Sept. 2, 1902
Ray, David Heydorn	
Archt. and Civ. Engr., 555 West 182d St., New York City.	Oct. 7, 1902
Ullmann, John George	
Asst. Engr., Buffalo Div., Erie R. R., Buffalo, N. Y.	April 1, 1902

CHANGES OF ADDRESS.

MEMBERS.

Auchincloss, William S. .... 45 West 20th St., New York City.
Ballard, Robert.. .... 35 Wood Lane, Shepherd's Bush, London, W., England.

Barber, William Davis............Asst. Engr. in Chg., Div. of Pumping Station, Constr. and Repairs, Dept. of Public Works (Res., 1639 Roscoe St.), Chicago, Ill.

Bisbee, Fred Milton..............Gen. Mgr., Los Angeles Land & Water Co., Los Angeles, Cal.

Child, Stephen....................Woodland Park Hotel, Auburndale, Mass.

Dewitt, Philip Hoffecker........8 Arlington Road, Cranford, N. J.

Ellis, George Ezra...............Western Agt., Pneumatic Signal Co., 1032 Monadnock Blk., Chicago, Ill.

Grant, Emerson Warren......... Eng. Dept., A., T. & S. F. Ry., 1014 West 13th St., Topeka, Kans.

Greene, Francis Vinton...........33 East 30th St., New York City.

Gresham, Robert Hall............San Angelo, Tex.

Grimm, Carl Robert..............131 Carnegie Hall, New York City.

Harlow, George Richardson .....620 Wood St., Wilkinsburg, Pa.

Hazlehurst, George Blagden.....376 East Colorado St., Pasadena, Cal.

Hyde, Abraham Lincoln...........Instr. in Civ. Eng., Lehigh Univ., 102 South New St., Bethlehem, Pa.

Irwin, James Clark...............Engr. of Signals, N. Y. C. & H. R. R. R., Grand Central Station, New York City (Res., 65 Glenwood Ave., Yonkers, N. Y.).

Jaques, William Henry............186 Devonshire St., Boston, Mass.

Jenkins, William Dunbar ....Div. Engr., Western Allegheny R. R., Chicora, Butler Co., Pa.

Kaufman, Gustave ....Engr. and Contr., 561 Franklin Ave., Brooklyn, N. Y.

Labelle, Henry Francis...........Civ. and Hydr. Engr., 1110 Betz Bldg., Philadelphia, Pa.

Le Baron, John Francis......... Chf. Engr., American Honduras Co. and Patuca Plantation Co., 1329 Williamson Bldg., Cleveland, Ohio.

Mosscrop, Alfred Mitton.........Vice Pres. and Mgr., Baltimore Bridge Co., Bush St. and B. & O. R. R., Baltimore, Md.

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Parker, Maurice Stiles...........Engr. and Contr., Arlington, Tex.

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Riffle, Albert Stanley...........Care, San Domingo Gold Mining Co., Angels Camp, Calaveras Co., Cal.

Ripley, Henry Clay...............Cons. Engr. for River and Harbor Impvts. and Marine Constr., 832 East University Ave., Ann Arbor, Mich.

Ruggles, William Burroughs.....Chf. Engr., Sandy Valley & Elkhorn Ry. Co., Pikeville, Ky.

Sims, Alfred Varley..............Iowa City, Iowa.

THOMPSON, ELLIS DUNN............U. S. Asst. Engr., 815 Witherspoon Bldg., Philadelphia, Pa.

TOMLINSON, ALFRED THOMAS........Lock Drawer "H," Albion, N. Y.

WALLACE, JOHN FINDLEY...........Gen. Mgr., I. C. R. R., 1 Park Row (Res., 4427 Greenwood Ave.), Chicago, Ill.

WEBB, GEORGE HERBERT...........Room 7, Arcade, Springfield, Ohio.

WEBER, ALEXANDER HAMILTON......U. S. Asst. Engr., Custom House, New Orleans, La.

WHITE, HENRY FISHER.............Engr., M. of W., C., R. I. & P. Ry., Room 605, Grand Central Station, Chicago, Ill.

WOERMANN, JOHN WILLIAM.........Res. Engr., Illinois and Mississippi Canal, Milan, Ill.

ASSOCIATE MEMBERS.

ALLAN, ALEXANDER GEORGE.........Res. Engr., A., T. & S. F. R. R., Lock Box 158, Newkirk, Okla. T.

ARCHER, STEVENSON, Jr............Res. Engr., Mo. Pac. Ry., Tallulah, La.

ARMITAGE, GEORGE WASHINGTON....Office of Constr. Quartermaster, U. S. A., U. S. Custom House and Post Office Bldg., Chattanooga, Tenn.

BARNETT, ROBERT CRARY...........3023 East 20th St., Kansas City, Mo.

BELLOWS, OSCAR FRANCIS...........Supt. of Constr., Q. M. Dept., U. S. A., Fort Ontario, Oswego, N. Y.

BISHOP, WILLIAM ISRAEL ....Care, Pittsburg Reduction Co., Massena, N. Y.

CARTER, ALFRED ELLSWORTH........Columbia Univ., New York City.

CARTER, SHIRLEY ....Norfolk, Va.

DEANS, CHARLES HERBERT ....130 Water St., New York City.

ELLIOTT, JAMES RUTHERFORD.......Care, Elliott & Baton, 1305 Keystone Bldg., Pittsburg, Pa.

FOSTER, THOMAS J.................Vice-Pres. and Mgr., National Bridge Supply Co., 116 Nassau St. (Res., 505 West 142d St.), New York City.

FRINK, FRED GOODRICH............1218 Washtenaw Ave., Ann Arbor, Mich.

GREENE, ROBERT MAXSON...........382 Greene Ave., Brooklyn, N. Y.

GUERINGER, LOUIS AMEDEE..........Asst. Engr., I. & G. N. R. R., Navasota, Tex.

HALLIHAN, JOHN PHILIP............Res. Engr. and Supt., Cananea Consolidated Copper Co.'s Ry., La Cananea, Sonora, Mexico.

HASSKARL, JOSEPH FREDERICK.......2504 North 5th St., Philadelphia, Pa.

HAUCK, WILLIAM..................742 St. Nicholas Ave., New York City.

JOHNSON, RANKIN..................Box 21, Ciudad Porfirio Diaz, Coahuila, Mexico.

LEWERENZ, ALFRED COURTNEY.......Naval Station, New London, Conn.

MILLER, SHREWSBURY BEAUREGARD..261 Union St., Hackensack, N. J.

MORRISON, EUGENE TAYLOR.........Supt., Levering & Garrigues Co., Dunellen, N. J.

NOBLE, FREDERICK CHARLES........1500 Grand Ave., Kansas City, Mo.
OSBOURN, HENRY VAN BUREN.......1433 Euclid Ave., Philadelphia, Pa.
RIGHTS, LEWIS DANIEL.............Care, American Bridge Co., Pencoyd, Pa.
ROCKENBACH, SAMUEL DICKERSON....Capt., 12th U. S. Cavalry, Office of Constr. Quartermaster, U. S. A., U. S. Custom House, Chattanooga, Tenn.
SHEPARD, HENRY HUDSON...........Care, D., L. & W. R. R. Co., Syracuse, N. Y.
SPENCER, JOHN CLARK..............Care, Brown Hoisting Machinery Co., Cleveland, Ohio.
TURNER, DANIEL LAWRENCE.........103 West 48th St., New York City.

ASSOCIATES.

SAPH, AUGUSTUS VALENTINE.........Instr. in Civ. Eng., Univ. of Cal. (Res., 2034 Durant Ave.), Berkeley, Cal.
TURRILL, SHERMAN MARSH...........Asst. Engr., Allen & Farrington, Municipal Engrs., 513 Dillaye Memorial Bldg., Syracuse, N. Y.

JUNIORS.

BELZNER, THEODORE...............Insp. of Steel Constr., Manhattan Valley Viaduct (Section 12), Rapid Transit R. R., 231 West 125th St. (Res., 142 West 67th St.), New York City.
BURWELL, ROBERT LEMMON.........Shortsville, N. Y.
CLEAVER, PITSON JAY...............113 Henry St., Brooklyn, N. Y.
FORBES, HENRY DE BRETTON........Engr., H. E. Talbott & Co., Sault Ste. Marie, Mich.
FORD, WILLIAM HAYDEN ....506 Hale Bldg., Philadelphia, Pa.
HARSHBARGER, ELMER DWIGHT......Rolla, Mo.
HIGGINSON, JONATHAN YATES........216 East 15th St., New York City.
KAST, CLARKE NIGHTINGALE ....270 Central Ave., Rochester, N. Y.
KLINE, VICTOR WITMER.............112 Hallett Pl., Bellevue, Pa.
LANT, FRANK PARSONS..............66 West 84th St., New York City.
MINOR, EDWARD EASTMAN..........493 Edgewood Ave., New Haven, Conn.
RHEA, WILLIAM DOUGLAS...........Manago National Fertilizing Co., Nashville, Tenn.
ROCKWELL, JAMES VINCENT.........Eagle Grove, Iowa.
RYDER, ELY MORGAN TALCOTT.......40 Whalley Ave., New Haven, Conn.
WAUGH, WILLIAM HAMMOND........Greenville, Pa.
WOOLLARD, GEORGE CLIFTON........Hornellsville, N. Y.
YOUNG, HENRY AMERMAN...........U. S. Engr. Office, Tuscaloosa, Ala.

DEATHS.

CLEVERDON, HENRY LAWRENCE......Elected Associate Member March 1st, 1899; died August 27th, 1902.
GELETTE, WILLIAM DURFEE.........Elected Member April 1st, 1885; died April 27th, 1902.

RESIGNATION.

Date of Resignation.

GILLIS, HARRY ALEXANDER...............................October 10th, 1902

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST.

(September 10th to October 7th, 1902.)

NOTE.—*This list is published for the purpose of placing before the members of the Society the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS.

In the subjoined list of articles references are given by the number prefixed to each journal in this list.

(1) *Journal*, Assoc. Eng. Soc., 257 South Fourth St., Philadelphia, Pa., 30c.
(2) *Proceedings*, Eng. Club of Phila., 1122 Girard St., Philadelphia, Pa.
(3) *Journal*, Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal*, Western Soc. of Eng., Monadnock Block, Chicago, Ill.
(5) *Transactions*, Can. Soc. C. E., Montreal, Que., Can.
(6) *School of Mines Quarterly*, Columbia Univ., New York City, 50c.
(7) *Technology Quarterly*, Mass. Inst. Tech., Boston, Mass., 75c.
(8) *Stevens Institute Indicator*, Stevens Inst., Hoboken, N. J., 50c.
(9) *Engineering Magazine*, New York City, 25c.
(10) *Cassier's Magazine*, New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 35c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News*, New York City, 15c.
(14) *The Engineering Record*, New York City, 12c.
(15) *Railroad Gazette*, New York City, 10c.
(16) *Engineering and Mining Journal*, New York City, 15c.
(17) *Street Railway Journal*, New York City, 35c.
(18) *Railway and Engineering Review*, Chicago, Ill., 10c.
(19) *Scientific American Supplement*, New York City, 10c.
(20) *Iron Age*, New York City, 10c.
(21) *Railway Engineer*, London, England, 25c.
(22) *Iron and Coal Trades Review*, London, England, 25c.
(23) *Bulletin*, American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gas Light Journal*, New York City, 10c.
(25) *American Engineer*, New York City, 20c.
(26) *Electrical Review*, London, England.
(27) *Electrical World and Engineer*, New York City, 10c.
(28) *Journal*, New England Water-Works Assoc., Boston, $1.
(29) *Journal*, Society of Arts, London, England, 15c.
(30) *Annales des Travaux Publics de Belgiqué*, Brussels, Belgium.
(31) *Annales de l' Assoc. des Ing. Sortis des Ecôle Spéciales de Gand*, Brussels, Belgium.
(32) *Mémoires et Compte Rendu des Travaux*, Soc. Ing. Civ. de France, Paris, France.
(33) *Le Génie Civil*, Paris, France.
(34) *Portefeuille Économique des Machines*. Paris, France.
(35) *Nouvelles Annales de la Construction*. Paris, France.
(36) *La Revue Technique*, Paris, France.
(37) *Revue de Mécanique*, Paris, France.
(38) *Revue Générale des Chemins de Fer et des Tramways*, Paris, France.
(39) *Railway Master Mechanic*, Chicago, Ill., 10c.
(40) *Railway Age*, Chicago, Ill., 10c.
(41) *Modern Machinery*, Chicago, Ill., 10c.
(42) *Transactions*, Am. Inst. Elec. Engrs., New York City, 50c.
(43) *Annales des Ponts et Chaussées*, Paris, France.
(44) *Journal*, Military Service Institution, Governor's Island, New York Harbor, 50c.
(45) *Mines and Minerals*, Scranton, Pa., 20c.
(46) *Scientific American*, New York City, 8c
(47) *Mechanical Engineer*, Manchester, England.
(58) *Proceedings*, Eng. Soc. W. Pa., 410 Penn Ave., Pittsburg, Pa., 50c.
(59) *Transactions*, Mining Inst. of Scotland, London and Newcastle-upon-Tyne.
(60) *Municipal Engineering*, Indianapolis, Ind., 25c.
(61) *Proceedings*, Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *American Manufacturer and Iron World*, 59 Ninth St., Pittsburg, Pa.
(63) *Minutes of Proceedings*, Inst. C. E., London, England.
(64) *Power*, New York City, 20c.
(65) *Official Proceedings*, New York Railroad Club, Brooklyn, N. Y., 15c.
(66) *Journal of Gas Lighting*, London, England, 15c.
(67) *Cement and Engineering News*, Chicago, Ill., 25c.

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The Proper Curvature for a Filled Arch.* Daniel B. Luten. (15) Sept. 12.
The Eighteen Mile Creek Viaduct.* (14) Sept. 20.
Unit Stresses and Impact in Old Railway Bridges. A. F. Robinson, M. Am. Soc. C. E. (13) Sept. 25.
New Kew Bridge.* (12) Serial beginning Sept. 26.
Warped Ends for Concrete Arch Culverts.* Daniel B. Luten. (15) Oct. 3.
Pont-Bascule de Milwaukee (États-Unis).* (33) Aug. 30.
Méthode de Calcul Rapide des Voûtes et de leurs Culées. C. Tourtay. (35) Serial beginning Sept.

Electrical.

The Arcophone or Speaking Arc Lamp. G. R. Smith and R. A. L. Snyder. (58) Aug.
The Use of Electricity in Iron and Steel Works.* F. Kylberg. (Paper read before the Iron and Steel Inst.) (22) Sept. 5.
The Application of Electric Power to the Iron and Steel Industries. D. Selby-Bigge. (Paper read before the Iron and Steel Inst.) (22) Sept. 5.
The New Electricity Works of the Corporation of Sunderland.* (26) Sept. 5.
Rational Electromagnetic Units. (27) Sept. 6.
Water Power Transmission for the Springfield, Mass., Lighting System.* (27) Sept. 6.
The Electrical Driving of Machinery; Its Economy and Advantages. Frank Broadbent, M. I. E. E. (26) Sept. 12.
The Up-Keep of the Direct Current Motor. Alfred H. Mayes. (26) Sept. 12.
Electric Power Distribution in the Black Country.* (26) Sept. 12.
The Power Equipment of the Westinghouse Works at Trafford Park.* (26) Sept. 12.
Electric Power in a Paper Mill.* (26) Sept. 12.
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The Kalgoorlie Electric Power and Lighting System.* (26) Sept. 12.
Electric Power, Light and Electric Welding Installation at the New Pimlico Wheel-Works.* (26) Sept. 12.
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Wireless Telegraphy and Maxwell's Theory. Frederick K. Vreeland. (27) Sept. 13.
Deterioration of Storage Battery Plates. A. L. Marsh. (27) Sept. 13.
Electric Power in Steam Railway Shops.* (27) Sept. 13.
The Electric Supply Power Station at Neptune Bank, Newcastle-upon-Tyne.* W. B. Woodhouse. (Paper read before the Inst. of Mech. Engrs.) (47) Sept. 13.
The Largest Electric Water Power Station in New England.* (27) Sept. 20.
Checking Electrical Instruments.* Clayton H. Sharp. (27) Sept. 20.
Construction of Transmission Lines. (27) Sept. 20.
The Use of Electricity in Iron and Steel Works.* F. Kylberg. (47) Serial beginning Sept. 20.
Newcastle and District Electric Lighting Company's Power Stations.* W. D. Hunter. (Paper read before the Inst. of Mech. Engrs.) (47) Sept. 20.
The Polycyclic Distribution of Electricity.* (26) Sept. 26.
Single-Phase Pumping Plant at Hammersmith.* (26) Sept. 26.
Wireless Telegraphy System of Prof. Braun and Siemens-Halske.* Emile Guarini. (26) Sept. 26.
Electric Power Transmission and Supply in Switzerland.* (12) Serial beginning Sept. 26.
Piscicelli Taeggi's Electric Post. William P. Digby. (11) Sept. 26.
The Sault Ste. Marie Water Power.* Frank C. Perkins. (27) Sept. 27.
The Belgian-Ougree Blast Furnaces and Steel Works and Modern Electrically-Operated Plant.* Frank C. Perkins. (19) Sept. 27.
The Physical Limits of Electric-Power Transmission. Alton D. Adams. (9) Oct.
Costs of Electric Power Transmission: A Practical Application of Principles. Alton D. Adams. (10) Oct.
An Interesting Fragment of Electrical History. (13) Oct. 2.
The Prevention of Electrolysis of Gas and Water Pipes in Great Britain. (13) Oct 2.
Apparatus of the Braun-Siemens & Halske System of Wireless Telegraphy.* (27) Oct. 4.
Emploi d'Electricité dans les Forges.* A. Abraham. (33) Aug. 30.
La Télégraphie sans Fil.* G. Espitallier. (33) Serial beginning Sept. 6.

Marine.

Steam Trials of H. M. S. *King Alfred*. (11) Sept. 5.
Some Early Submarine Torpedo Boats.* G. W. Baird. (Reprinted from the *Journal of the Amer. Soc. of Naval Engrs.*) (13) Sept. 11.
The French Battleship *Republique*.* (12) Sept. 12.
On the Strength of High-Speed Vessels. M. J. A. Normand. (11) Sept. 12.
The Steam Yacht *Arrow*—the Fastest Boat in the World.* (46) Sept. 20.
The *Kaiser Wilhelm II*, the Longest Steamship ever Constructed.* (13) Sept. 25.
The British Fleet, 1889–1902.* Archibald S. Hurd. (10) Oct.
Résistance des Carènes. Chaigneau. (36) Serial beginning Aug. 25.

Mechanical.

Rotative Pumping.* John Richards. (1) Aug.
The Deutz Gas-Motor Works.* (11) Sept. 5.

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Mechanical—Continued.

The Compression of Steel by Wire-Drawing during Solidification in the Ingot Mould.* A. Harmet. (Abstract of paper read before the Iron and Steel Inst.) (22) Sept. 5.
Tests of Steam Turbine Installed at Hartford, Conn. Wm. Lispenard Robb. (27) Sept. 6
The Erection and Working of Inclined Retort Settings. E. Merz. (Reprinted from *Journal für Gasbeleuchtung.*) (66) Sept. 9.
Gas Engines for Central Station Work. Charles H. Williams. (62) Sept. 11.
Specifications for Foundry Supplies. (13) Sept. 11.
Shop Tools and Rigs.* James A. Murphy. (47) Sept. 18
Proper Charging of Ammonia Compression Plant. (62) Sept. 18.
Superheat and Superheaters. H. Cruse. (Reprinted from *Engineering Times.*) (62) Sept. 18.
The Works of Messrs. Belliss and Morcom, Limited.* (11) Sept. 19.
Recent Progress in Large Gas Engines.* Herbert A. Humphrey, M. I. Mech. E. (Paper read before the British Assoc.) (11) Serial beginning Sept. 19.
Inclined Retorts at the Vaise (Lyons) Gas-Works.* M. Godinet. (Paper read before the Société Technique du Gaz en France.) (66) Sept. 23.
Cable-Guided Gasholder at the Rodez Gas-Works.* M. Godinet. (Paper read before the Société Technique du Gaz en France.) (66) Sept. 23.
Steam Generation for Large Rolling Mills.* J. R. Bibbins. (20) Sept. 25.
The Smokeless Combustion of Bituminous Fuels. W. H. Booth, M. Am. Soc. C. E. (Abstract of paper before the British Assoc. for the Advancement of Science.) (26) Sept. 26.
New Types of Cranes.* Waldon Fawcett. (62) Sept. 25.
The Daw Air-Compressor. (11) Sept. 26.
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The Power Plant of the Stecher Lithographic Company, Rochester, N. Y.* (14) Sept. 27.
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The Steam Engine at the Dusseldorf Exposition.* (64) Oct.
Cast *vs.* Wrought Iron Steam Mains.* C. G. Robbins. (64) Oct.
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Safe Speeds for Flywheels. Wm. H. Boehm, M. Am. Soc. M. E. (Reprinted from the *Monthly Bulletin of the Fidelity and Casualty Co.*) (13) Oct. 2.
The Calculation of the Weight of Castings with the Aid of the Planimeter. C. M. Schwerin. (Paper read before the Amer. Inst. of Min. Engrs.) (13) Oct. 2.
The Suppression of Smoke in Steam Plants Using Bituminous Coal. Albert A. Cary. (20) Serial beginning Oct. 2.
Improvements at the Schenectady Works of the American Locomotive Co.* (15) Oct. 3.
The New Power Plant for the Assabet Mills, Maynard, Mass.* (14) Oct. 4.
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Les Progrès des Moteurs à Gaz: Le Nouveau Moteur Niel. Auguste Moreau. (32) Aug.
Concours International de Moteurs et Appareils Utilisant l'Alcool Dénaturé. I, Appareils d'Éclairage et de Chauffage par G. Arachequesne; II, Moteurs par G. Coupan. (32) Aug.
Étude sur les Machines-Outils Utilisées dans le Travail de Bois.* Paul Razous. (37) Aug.
Les Machines à Jet de Sable.* A. de Riva-Berni. (33) Sept. 6.
Les Machines à Vapeur à l'Exposition de Dusseldorf.* P. Dujardin. (33) Sept. 20.

Metallurgical.

The Progress and Manufacture of Pig Iron in Germany since 1880. W. Brugmann (Paper read before the Iron and Steel Inst.) (11) Serial beginning Sept. 5; (22) Sept. 5.
Progress in Steel Works Practice in Germany since 1880. R. M. Daelen. (Paper read before the Iron and Steel Inst.) (11) Sept. 5; (22) Sept. 5; (13) Sept. 25.
The Works of the Skinningrove Iron Company.* (22) Sept. 12.
The Designing and Equipment of Blast Furnaces.* John L. Stevenson. (12) Serial beginning Sept. 12.
The Overheating of Mild Steel. E. Heyn. (Paper read before the Iron and Steel Inst.) (11) Serial beginning Sept 12.
Electrogalvanizing. C. F. Burgess and Carl Hambuechen. (27) Sept. 18.
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Aluminum as a Reducing and Heat Producing Agent. H. Hofman. (62) Sept. 25.
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Electro-Metallurgical Problems. Alec. A. Beadle, A. I. E. E. (26) Serial beginning Sept. 26.
The Metallurgy of Titanium. Auguste J. Rossi. (3) Oct.
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The Steel Plant at Monterey, Mexico. William White, Jr. (62) Oct. 2.
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Metallic Conduction and the Constitution of Alloys. John Alexander Mathews. (27) Oct. 4.
La Métallurgie du Fer et de l'Acier à l'Exposition de Düsseldorf 1902. Alexander Gouvy. (32) July.
L'Aluminothermie et ses Applications. H. Bertin. (32) Aug.
Forges et Aciéries d'Anvers.* (36) Sept. 10.

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Ordnance Engineering as a Mechanical Industry.* J. F. Meigs. (9) Oct.

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Mining in Japan: A Description of the Mines and Plants of the Hokkaido Tanko Tetsudo Kaisha.* Fritz J. Frank. (45) Sept.
Pick and Chain Machines: A Comparison of the Two Types from the Standpoint of an Advocate of Pick Machines. L. J. Daft. (45) Sept.
Gold Mining in the Transvaal, South Africa.* John Hays Hammond. (45) Sept.
Mining Explosives: The Effect of Perfect and Imperfect Detonation.* A. W. Warwick. (45) Sept.
Winding Plants for Great Depths. Hans C. Behr. (45) Sept.
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The Economic Theory of Shafts and Slopes for Flat Coal Beds. E. Brackett. (16) Serial beginning Sept. 20.
Damping the Air of Coal Mines as a Safeguard against Explosions. James Ashworth. (22) Sept. 26.
Recent Changes in Mining and Milling in the Galena-Joplin Lead and Zinc District.* W. R. Crane. (16) Sept. 27.
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Mining Industry and Mineral Resources of British Columbia. Wm. M. Brewer. (9) Oct.
The Beaumont Oil Field. Robert T. Hill. (13) Oct. 2.

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The Foundations of the American Iron Industry. Archer Brown. (9) Oct.
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Relation Between Macadam Roads and Electric Street Railways. Edward P. North, M. Am. Soc. C. E. (Paper read at Third Annual Good Roads Convention.) (14) Sept. 18.
Removal of Snow and Ice in the Borough of Manhattan. W. Boardman Reed. (Paper read before the New York State Street Ry. Assoc.) (17) Sept. 13.
Paving a Country Road with Brick. Sam. Huston. (Paper read before the Ohio Soc. of Civ. Engrs. and Surv.) (13) Sept. 25.
Methods Employed in the Construction and Maintenance of the Massachusetts Pipe Line Gas Co.'s Mains in Boston and Vicinity.* W. W. Cummings, M. Am. Soc. C. E. (13) Oct. 2.

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* Illustrated.

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The Proper Handling of Compound Locomotives.* W. J. McCarroll. (Abstract of paper read before the Traveling Engrs. Assoc.) (15) Sept. 26.
The Tractive Force of Locomotives. Edward L. Coster, A. M. Am. Soc. M. E. (25) Oct.
Steel Rails: Specifications. Robert Job. (25) Oct..
The Relation between Heating Surface and Cylinder Power: A Measure for the Steaming Capacity of Locomotives. Lawford H. Fry. (25) Oct.
Six-Coupled Switching Locomotive, Lake Shore & Michigan Southern Railway.* (25) Oct.
The Lighting of Railway Trains in Europe.* H. Guérin. (9) Oct.
New Locomotive and Car Shops, Collinwood, Ohio; Lake Shore & Michigan Southern Railway.* (25) Serial beginning Oct.
The Third-Rail Electric System on the New York, New Haven & Hartford R. R. (13) Oct. 2.
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The Street Railway System of Providence, Rhode Island, and Vicinity.* George B. Francis. (1) Aug.
Street Railway Track Construction in City Streets.* Arthur L. Plimpton. (1) Aug.
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Tests of Interurban Cars of Union Traction Company.* Clarence Renshaw. (17) Oct. 4.
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Problems in Maintenance of Purity, Equability and Moisture of Air in Dwellings. P. H. Bryce. (67) Sept.
Engineer's Report on the Garbage Furnaces of Trenton, N. J. Rudolph Hering. (13) Sept. 11; (14) Sept. 13.
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An Engineering Commission on the Artesian Wells of the Memphis Water-Works. (13) Sept. 25.
Electric Power Transmission and Supply in Switzerland.* (12) Serial beginning Sept. 26.
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A List of Failures of American Dams. W. R. Hill, M. Am. Soc. C. E. (From Presidential Address before the Amer. W. W. Assoc.) (14) Sept. 27.
The Sault Ste. Marie Water Power.* Frank C. Perkins. (27) Sept. 27.
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AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

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Vol. XXVIII. OCTOBER, 1902. No. 8.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

AN ALTERNATIVE LINE FOR THE NICARAGUA CANAL; AND A PROPOSED NEW METHOD OF DAM CONSTRUCTION.

By J. Francis Le Baron, M. Am. Soc. C. E.

To be Presented November 19th, 1902.

1.—An Alternative Line for the Nicaragua Canal.

The importance of good harbors for the termini of the Nicaragua Canal is so great that we could well afford to sacrifice several less favorable features to secure them.

On the Pacific side, Brito seems to be the only available terminus, and a harbor will have to be constructed there.

On the Atlantic side, however, there is more choice; but, strange to say, only one location for the harbor has been proposed. This appears all the more strange when the fact is considered that Greytown Harbor was ruined nearly forty years ago by the sand drift from the east, and the whole bight of the coast in which Greytown is situated is in a state of unstable equilibrium, and has been from remote geological periods. This is shown conclusively by the succession of lagoons, five in number, beginning with Silico and ending with the

Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

present harbor lagoon, which have been formed one after the other by the westward littoral sand drift projecting itself in the form of a spit across the re-entrant coast angle and thus forming a progressive delta, which now projects fully 2 miles from the normal coast line, and which shows a growth of 9 miles into the sea, since the action began at the ancient shore line of Silico Lagoon.

The majority of this sand, but not all, comes from the Colorado mouth of the San Juan, and is transported westward by wave action along the beach, on which the waves strike diagonally, under the influence of the prevailing easterly winds. The writer investigated this subject carefully when in Nicaragua, and discussed it in his report to the Maritime Company, in 1888.

The conditions at the mouth of the Colorado are quite different, and present a nearly stable equilibrium. Since 1865, when this whole region was surveyed by Assistant P. C. F. West, of the United States Coast Survey, there has been no appreciable change, up to the present time, at the Colorado mouth, while great changes have taken place at Greytown, as shown on the series of charts printed in the Report of the first Nicaragua Canal Board, and ably discussed by them.* The writer, however, must disagree with the able Commissioners' statement that a neutral point of equilibrium exists midway between Harbor Head and the bight where the Canal Company's canal mouth is situated. The whole geological and physical evidence of this locality points conclusively to the fact that the whole littoral, from the highlands at the mouth of the Colorado to the present canal mouth, is in a condition of constant accretion, and from the mouth of the Rio Tauro it presents a progressive curtain traveling northwestward nearly parallel to the shore line as now existing from the canal northward and northwestward, each succeeding decade removing the bight or re-entrant angle further to the northwest, which motion resembles that of an immense mole, or rather a sand wave of progression, traveling up the coast.

This view is sustained by the current observations which the writer took in the bay between Harbor Head and the canal mouth, and which, ¼ mile off shore, were found to have a direction leading directly into the bight, and normal to the coast line west of the canal.

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* Page 83 *et seq.*

These facts show plainly the futility of attempting to make a harbor in this re-entrant, and the utter impossibility of restoring the Harbor of Greytown.

This action of the littoral is assisted by the detritus and trash brought down by the Lower San Juan Branch, which is constantly extending and increasing the swamp lines near its mouth, as shown by examination of the old charts, and is plainly seen by daily examinations, such as the writer made while in charge of the canal works there.

This condition was clearly understood by Major McFarland, of the United States Engineers, who examined and reported on this harbor and the canal line in 1876, and who, for this reason, advocated the location of the canal mouth to the eastward of Harbor Head, at the salient angle of the coast, where a condition of more stable equilibrium exists. The futility of building a harbor in the re-entrant angle is exemplified still further by the experience of the Maritime Canal Company.

The jetty built by them has been overwhelmed by the sands, and the channel they had cut through the littoral cordon enclosing the harbor lagoon filled up shortly after the work stopped. Since then it has opened again, on account of the action of the floods in the San Juan River, of which it now forms one of the mouths. This latter cause may preserve an intermittent channel here, but it will constantly decline in depth as the outflow of water from the rapidly shrinking Lower San Juan becomes less and less. It is the outflowing water alone that can preserve it. There is now a depth of only 6 ft. in the channel where there had been 16 ft., and a new spit is extending itself northwestward from Harbor Head to form eventually a new lagoon in front of the present one.

The Colorado mouth will now be considered. The advance of the shore line from the Highlands of the proceeding geological horizon is only 2 miles, as compared with 9 miles at Greytown, in the same time, and appears now to be about stationary. The Colorado Branch carries three-quarters of the water of the San Juan, and the lower part of the San Juan has been growing shallower from year to year, and filling up, until it has now become so shallow as to be unnavigable, and the Steamboat Company who used it on their weekly trips to the Lake have been obliged to discontinue its passage, and have built a railroad

from Greytown to near the Colorado Junction. The Colorado Branch shows a nearly uniform depth of from 24 to 30 ft. from the bar up to the mouth of the Caño Bravo, a distance of nearly 7 miles, with one stretch of from 12 to 17 ft. depth, about 1½ mile in length, and nearly ¼ mile in average width.

There are three parallel lagoons, called collectively "Agua Dulce Lagoon," on the north side, running nearly parallel to the shore line, which present the appearance of old river beds nearly at right angles to the present course of the river.

These lagoons are 4, 7½ and 8½ miles long, respectively, and each is about ¼ mile wide. They have a depth of from 12 to 24 ft.

South of the river, near the mouth and connected with it, there is an old river channel, called Simon Lagoon, having a length of 3¾ miles and an average width of ¼ mile. These lagoons and channels are all connected with the river, and furnish a harbor of 3 800 acres, besides the river itself, which is of sufficient width and depth to allow vessels to tie up to the bank on each side in the straight reaches, thus affording room, altogether, for 700 vessels of nearly 12 ft. draft, and about 20 vessels with a draft of 24 ft. Its capacity could readily be increased by a little dredging to accommodate 100. This harbor is only 1 mile from the 30-ft. sea-curve. The depth of water on the bar varies from 8 to 11 ft. at low water. The writer examined this bar in 1888, and considers it well adapted for improvement by jetties, as it consists of the same light volcanic sand as composes the beach at Greytown, and the distance out from shore to the 30-ft. curve is only about 2 500 ft.

The rise of the tide is only 15 ins. at Greytown, about 14 miles to the northwest, and would be practically the same here, and there is no inflowing current. The velocity of outflow is from 3 to 4 ft. per second, and the volume of discharge, at a low stage, is 16 000 cu. ft. per second, as measured by Major McFarland. This is likely to be increased fourfold in floods, and will never fall much below it. The depth just inside the mouth is 30 ft.

There seems to be little reason to doubt that this channel can be deepened to 24 ft., by jetties alone, especially when it is considered that now almost no water passes through the San Juanillo from the San Juan, and that the Lower San Juan is rapidly filling up and in a few years practically all the water of the San Juan will pass through the Colorado outlet, thus increasing the scouring power.

The land on the south side of the river, at the mouth, is high and sightly, and very eligible for a port, and the shape of the lagoons is such as to afford not only a most secure and land-locked harbor, but also excellent facilities for coaling and loading and unloading ships. The depth over the bar can be easily increased by dredging to the extent required after the jetties are built, or probably by dynamite alone, because, owing to the swift outflowing current and contracted channel caused by the jetties, the problem would be much simpler than that presented at Brunswick, and the depth once gained can be easily maintained by contraction works, on the plan adopted at the South Pass.

This harbor appears to the writer to be the great desideratum now lacking in the Nicaragua scheme, and he believes it can be made to fill all the requirements with but slight cost; not so much, in fact, as would be required to make a harbor at Greytown, which, in combatting all the forces of Nature, would require constant effort to keep open, while here the mighty force of the river will aid. In the one case we are fighting Nature, in the other we are aiding her.

The way by which this harbor can be made available will next be described.

The last Isthmian Canal Commission dismissed the idea of a canal on the south side of the San Juan in a few words, but these were calculated to prejudice any one against a canal on that side, wrongfully, as it seems to the writer, inasmuch as they stated that more streams would have to be crossed on that side, stating them as follows: Frio, Poco Sol, San Carlos and Serapiqui. The Chief Engineer, in his report,* says:

"An examination of the map shows that a canal location from the Caribbean Sea to Lake Nicaragua, south of the San Juan River, would cross all of these streams. This would make its construction practically an impossibility."

Inasmuch as the plan presented by the Commission contemplates the construction of a dam at Conchudo just above the mouth of the San Carlos River and below the Frio and Poco Sol Rivers, the flooding of the river valley from this Conchudo dam to Lake Nicaragua up to the level of the lake, and the use of this part of the river for slackwater navigation, it is difficult to see how the entrance of these rivers

* Page 54.

on the south side affects the problem in any different manner than if they had happened to enter on the north side.

Really, the only streams that affect the problem are those which enter below the dam, and not above, as the canal must cross those that enter on the same side on which the canal is located.

If the canal is located on the north bank of the San Juan River, it must cross the following streams below the Conchudo dam, viz.: The Danta, San Francisco, Negro, San Juanillo (twice), and Pescado Rivers, and the Mochado, Tamborgrande, Tamborcito, Guasimo and Misterioso Creeks, making eleven crossings.

If on the south side, it would cross the San Carlos and Serapiqui Rivers and the Cureño, Tamborcito, Maria and Tigre Creeks (seven crossings); showing four in favor of the south side, but the two largest, the San Carlos and Serapiqui, are on this side. The latter is a deep stream of moderate velocity near the mouth where the canal would cross it, but it is no more difficult than the San Francisco, except in degree, it being about twice the size of that stream and subject to about the same rise in freshets, viz., 12 ft. Its crossing could be effected without difficulty by placing a lock in the canal on each side and a movable dam in the river below. The other streams, with the exception of the San Carlos, are small, and present no difficulties. The San Carlos will be merged in the lake created by damming the San Juan. The plan proposed by the writer for consideration is as follows:

To locate the canal on the south side of the San Juan River from Ochoa to the mouth of the Colorado; to build the dam at Ochoa from the north end of the San Carlos embankment hill (but not on the northeast course) to a point east of the mouth of Mochado Creek, as proposed on the old Canal Company's plan, but from the same point as proposed in that plan on the San Carlos Ridge in a direction northwest by west to the high rocky hill west of the mouth of the Mochado, allowing that creek to enter the river below the dam. All the borings taken at this locality tend to show the rock to be much nearer the surface above the dam site than below, and the geological formation indicates this; but, even if the bed-rock is as deep here as on the location adopted for the Canal Company's line, the construction of a stable and permanent dam here, the writer believes, will present no difficulty on the plan he proposes, and which he will discuss later.

Premising, then, that a dam is feasible here, this dam would raise the water in the river to 110 ft. above sea level, and the San Carlos Basin would be formed by building twenty-three small embankments on the saddles of the hills forming the San Carlos Ridge line, fourteen of which would be less than 15 ft. in height, and all with solid foundations. Ample sluices would also be built in this ridge line for the escape of the flood waters of the San Carlos, as proposed in the Canal Company's plans, and the Ochoa dam would be built as a weir to allow the escape of the flood water over the top, which plan would be perfectly safe by the method of construction herein proposed, and which will be described later.

(The United States Commission states* that there would be no difficulty in building the San Carlos embankment.)

The canal line would start, then, from the San Carlos Ridge, with a lock in both the upper and lower ridges, and would run down the valley of Cureño Creek, through Cureño Lagoon in a straight line to and across the Serapiqui River; then a curve of large radius would deflect it to the north to pass near the southern bend of the Colorado River through the bayou called Rio Blanco; thence, another curve to the left would allow a tangent to be laid passing through Colorado Lagoon direct to the Colorado River at the junction of Simon Lagoon; thence, following the river, a distance of 3¼ miles to the sea. It will be noticed (see Plate XXXVIII) that the Serapiqui River is crossed in one of the bends, so that the current will be taken straight instead of broadside. By this location only four curves will be required in the canal, and these can be of as large radius as may be desired, as against twenty-one curves on the line laid down and recommended by the Commission, nine of which have a radius of only 3 280 ft., and two of 3 000 ft., while several of them are reversed curves. These numerous sharp curves are very objectionable. The chief difficulty in navigating the Suez Canal occurs on the curves, where ships of deep draft are very apt to take the ground. For this reason it would be found impracticable to operate the canal at night.

The part of the river used for the canal near the mouth is nearly straight, with no sharp curves, and the water is from 18 to 30 ft. deep. On this line there would be no cut of more than 56 ft. to the water grade, except at one or two knife ridges.

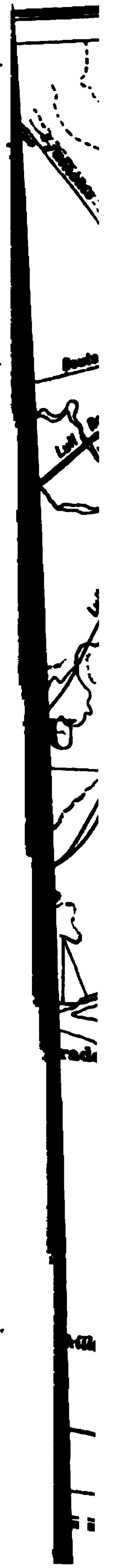

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PLATE XXXVIII.
PAPERS, AM. SOC. C. E.
[redacted]
LE BARON ON ROUTE OF NICARAGUA CANAL.

The canal would be wholly in excavation from the San Carlos Ridge line to the sea, and the length from the San Carlos Basin to the 30-ft. curve in the Caribbean Sea is 44.49 miles, as against 45.15 miles by the Commissioners' line, a difference of 0.66 mile in its favor; but, as 3½ miles of the proposed line is in the Lower Colorado, where the depth varies from 18 to 30 ft., this part of it will require so little dredging that it practically reduces the length of canal in excavation to 40.49 miles, and effects a saving of 4 miles of canal to be excavated.

The flood line of the Colorado River at the point where the canal enters is only about 3 ft. above the low-water stage, so that it will be quite practical to lock into the river and use it for the lower end of the canal.

While in charge of the surveys and works of the Canal Company in 1888–89 the writer sent a party to examine and survey Cureño Creek, and another to examine the land southeast of the mouth of the Serapiqui River. In the former case the lands on both sides were reported low, with many lagoons, until the hills of the San Carlos Ridge were reached, and in the latter case the land was reported to be all wet swamp, with occasional isolated hills, for many miles in all directions. In 1887 the writer reconnoitered the San Carlos Basin. In 1888 he had the San Carlos Ridge line surveyed and personally examined it. During the same year he made a compass reconnoissance of Trinidad Creek, Manitee Lagoon, and the adjoining lands; and in 1889 he examined the Colorado River and Bar, observing that the land near the river was nearly all low and swampy. In 1888 he also sent a party to reconnoiter the land in Costa Rica south of San Francisco Island, and it reported low rolling hills, without any high land.

In 1898 the Isthmian Canal Commission caused a survey and reconnoissance to be made of Tamborcito Creek and the adjoining territory east to Manitee Lake. This examination covered Tamborcito Lagoon, and showed the character of the country to be low and swampy, with isolated hills and a few broken ridges.

These different surveys and reconnoissances practically cover the whole line, taken in connection with the observations made by the writer from the high pilot house of a steamer on the San Juan River, which failed to discover any high land on the south bank of the San Juan, until nearly up to Ochoa, except a few detached hills.

These examinations are sufficient to justify a survey of this line, and to warrant the statement that in all probability a practical and even favorable line can be located. It is quite possible that on the actual location it may prove to be desirable to introduce one or two more curves to improve the profile and avoid high hills, but, after leaving the San Carlos Ridge line, the surface, for the most part, with the possible exception of a short stretch opposite San Francisco Island, will be found to be elevated only a few feet higher than the bank of the San Juan River. This is absolutely known for nine-tenths of the distance to the sea. No rock has been observed on this line, and it is not believed that any large amount will be found. What there is will probably consist of medium-sized boulders. It is also possible that when the actual location is made the line can be improved considerably.

Until this line is definitely located, an accurate estimate of the cost is impracticable, but a tolerably close estimate is possible for one familiar with the country. The summit level being the same as that prepared by the Commission, there will be the same rise and number of locks, but the deep rock-cut at the mouth of the San Carlos River, and the other heavy rock-cuts at Tamborcito, Serapiqui, San Francisco and the vicinity of Silico Lagoon will be entirely eliminated, and the only heavy cuts encountered will be those at the lock sites, which are necessary in all cases.

The earth excavation will be red, white and blue clay, and swamp muck. This is predicted from the surface indications, the eroded hills, the river and creek sections along the line, and the borings taken on the San Carlos Ridge line. There will be no excavation in the San Carlos Basin, a distance of 3 miles, to give a 30-ft. navigation, and for the lower Colorado, where the line runs in the river for 3 miles, the depth of dredging required will average only 6 ft.

From the approximate estimate made by the writer, the line on the south side, herein described, can be built for about $17 000 000 less than the Commission's line on the north side.

The strong outflowing current of the Colorado is required to maintain the channel through the beach to the sea. Without this agency the canal mouth can only be kept open by constant dredging, at great yearly expense. The greater part of the discharge, however, if desired, could be turned down the Lower San Juan by constructing deflecting dikes and a barrage at the head of the Colorado.

A modification of the line herein proposed would pass into the Colorado River at the head of the Rio Blanco and continue therein to the sea. This location would only be made in the interest of economy, but is feasible by making some cut-offs and straightenings, and would reduce the cost about one-half for a distance of 12 miles.

It is contended by some that the San Carlos Basin will be filled up by sand brought down by the river. It seems to the writer that this contingency is very remote. This basin is 9 miles long and 4 miles broad, and the river enters 8 miles above the San Juan River. The average depth of the basin will be about 40 ft., and there will be about 75 to 80 ft. in the channels. When the basin is flooded, the San Carlos will enter the lake 8 miles from the canal sailing line and will deposit its load of sand as soon as it enters the still waters of the lake. It must be considered that the upper part of the river, above the basin, is rocky and contains but little sand, the river bed having been well washed, and that most of the sand now comes from the lower part, which then will be in the lake; consequently, the sand movement will be much less than it is now. Even if this basin should fill up in the course of 500 years, the canal could still be dredged through it, as in other places.

2.—Dam Proposed at Ochoa, on the Nicaragua Canal.

The writer believes that a masonry or monolithic dam would be highly objectionable, either at Panama or Nicaragua, on account of the great damage that might be done to it in a few moments by an earthquake, and which might require several years to repair, and in the meantime the canal would be closed.

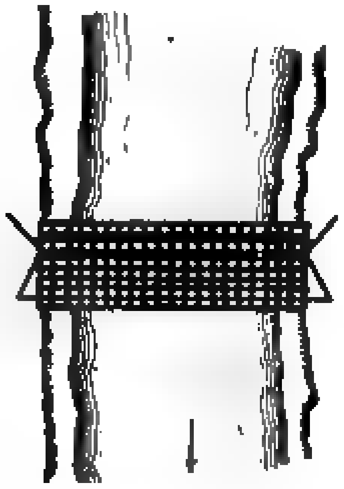
Any method of construction which can be substituted, which will be free from this danger, and which is at the same time a safe and practical plan should be considered attentively and welcomed gladly.

The plan recommended by the Advisory Board of Consulting Engineers to the Canal Company was for a looserock dam, 30 ft. wide on the crest and 500 ft. on the base, with up-stream slopes of 1 to 1 and down-stream slopes of 4 to 1, and a total height of 70 ft. This was increased by the First United States Canal Commission to 950 ft. on the base, up-stream slope 1 to 1, down-stream slope 10 to 1 at the toe, increasing to 4 to 1 at the crest, with a width of 20 ft., and this rock fill was to be backed on the up-stream side by an earth, gravel, and chip backing, 20 ft. on the crest and having an up-stream slope of 5 to 1, with a base of 340 ft.

The writer proposes a loose-rock dam, enclosed in a heavy chain-cable net, with a base of 360 ft., a crest of 10 ft., an up-stream slope of 1 to 1, and a down-stream slope of 4 to 1, as shown in Fig. 2.

The chain composing the net would consist of 1-in. ship's cable, forming meshes 3 ft. square. These meshes would be crossed by two ½-in. cable chains making four meshes of 18 ins. square, all to be linked together securely by split links or shackles at the crossings, as shown in Fig. 2. This net would first be laid flat on the river bottom (Fig. 1), from shore to shore, and extending up the banks to the top of the dam, and up stream and down stream above and below the dam a sufficient distance, so that, when the dam is built to its full height, the ends from the top and bottom can be brought up and fastened together on the top of the dam.

The net would also be continued on the bottom of the river, above and below the dam, as an apron, 100 ft. at each end, laid flat on the bottom of the river and covered with about 2 to 3 ft. of rock (Fig. 3). This chain net would accommodate itself to the inequalities of the bottom of the river, and would promptly sink into and fill any holes formed by scouring. As the dam settled from this cause, stone would



PLAN.
FIG. 1.

FIG. 2

FIG. 4.

a cable

be added on the top until a condition of stable equilibrium was secured. The chain net would give cohesiveness and stability to the structure, which would thus be made a unit. The bed should first be dredged out as deep as it could be conveniently.

To prevent the dam being broached during construction the net would be brought up on the down-stream slope from time to time to keep pace with the growth of the mound, and, being securely linked to the sides and front ends as the work progressed, would effectually prevent the degradation of the crest, no matter what depth of water was passing over.

This method of construction would present no difficulties, and the structure when completed would present no conditions that could not be readily computed. As the work progressed, sufficient broken stone and gravel would be thrown in to fill all voids of the dam, and after its completion more gravel, sand and clay would be thrown in on the upper side to make it water-tight. This material would be sucked in among the loose rocks by the current. Wing trenches in the banks would first be excavated to rock or carried to solid masonry flanks, and these trenches filled with the chain net, and the enveloped rock would be in turn linked to the main dam.

The cost of such a dam would be far less than that of a masonry dam, and could be built in half the time. It would be perfectly safe as a weir; an earthquake would only serve to consolidate it and fill up the voids, and it could not slide or be overturned. The rock would be that taken out of the canal prism, which would otherwise be wasted.

The First United States Commission, of which the late Gen. Ludlow was chairman, did not consider impracticable the building of a loose-rock dam at Ochoa, with the modifications that they proposed. The chief danger that they anticipated lay in broaching the crest of the dam by the deep over-rush of flood waters. This is evidently impossible when the rock is confined in a chain-cable net, with the links of the cable 1 in. in diameter. In suggesting this dam for the consideration of the Society, it is with no desire to criticize the able Commission or their engineers, but solely for the purpose of examining all sides, as would seem desirable and proper in a work of this magnitude and importance, before deciding definitely upon a route. Even in the event of the Nicaragua route being selected, it could be greatly improved, straightened and reduced in cost, between the San

Francisco hills and Serapiqui Ridge, by continuing the curve a few more stations at San Francisco, and running more to the north and further from the river in a direct line to Caño Sucio (see Plate XXXVIII). This would do away with three curves, two of which are reversed curves of very short radius for a canal, *i. e.*, 3 820 ft., and would substitute a tangent 6 miles long for the crooked and expensive line recommended by the Commission. It would be nearly all in swamp, and would eliminate the heaviest cut, 230 ft. in depth, on the Commissioners' line, namely, that at Tamborcito Hill. The writer knows this because he surveyed the line in 1888.

A dam of this character is not a wholly untried experiment. Many years ago the writer built a small dam similar to this, but the net was made of twine, and sand bags were substituted in place of rock, it being intended to serve a temporary purpose. In this case, for the base, a cross-trench was dug with shovels, and the dam was first built up of sand bags alone. These were washed off, however, and then the writer conceived the idea of enveloping the whole dam in a net. An old fish net was pressed into service, and the dam was rebuilt and enveloped in it. There was no further trouble; the dam stood and resisted a pressure of about 9 ft. and a flood of 18 ins. over the crest.

Suppose the stream has a velocity of 6 ft. per second and a depth of 15 ft. over the top of the dam, conditions that probably will never be exceeded; also, suppose a mahogany log, 20 ft. in diameter and 60 ft. long, should be brought by the current end on against the dam; assume that this log would have the same velocity as the stream, viz., 6 ft. per second, and that its weight would be 942 480 lbs. $\div$ 2 000 = 471 tons.

The strain of a force pressing against the center of the net would be transmitted in one-quarter ratio from link to link of the chain to the ends of the net or to some point where the net is immovably held by projecting rock or to a corner or sharp edge that holds the net immovable. The strains thus transmitted in all directions would be modified more or less by the friction of the chain net on the rocks, or by its partial fixation by sharp projections which would not prove actually immovable. The strains would also be transmitted by pressure through the rock mass of the dam to the chains on the opposite sides and ends. The amount of these transmitted strains would be modified by the solidity of the rock mass and its stability,

for it is plain that if the rock mass were perfectly immovable no strains would be transmitted to the opposite chains, but, in the case of a loose rock-fill dam, the pieces of rock composing it would have a certain freedom of motion over each other, and those on the crest would be likely to be pushed over and off the crest by a sufficient force, if not withheld by the cables.

The forces tending to produce this result would be the impact and lifting force of the water applied along the whole crest of the dam, and the force produced by the impact of any large body, such as a log floating with the current. The net being divided into squares by 1-in. chains, and these again into four smaller squares, by ½-in. chains, those squares against which the moving body impinged would be called upon to sustain all the strain, provided the adjoining squares to which they were connected were held rigidly; but this not being the case, the strain would be transmitted to the next square and the next, and so on, each square resisting a certain amount in proportion to the friction of that particular square on the loose rock on which it was lying, which friction would be greatly modified by the projecting corners of rock within each square. In other words, if the chain net were simply suspended vertically across the river entirely free from the dam, the strains would be transmitted equally in all directions to the ends. The question then resolves itself into the friction of a heavy chain net on a rough bed of loose rock, each piece averaging, say, 100 lbs. in weight, and being more or less firmly fixed in its bed by the adjacent rocks of different sizes. In the absence of any experiments as to the amount of such friction it can only be assumed that it would increase in direct proportion to the distance from the point of application of the force. It is evident, then, that at a distance, x, from the point of application, the friction would absorb all the strains, and that part of the chain lying beyond would be unstrained. This distance would depend upon the roughness of the bed, and the amount and character of the bends in the line of strain. If this distance were short a certain proportion of the strain would be transmitted around the ends or faces of the dam, and would be taken up by the chain on those sides or ends. This would also be modified by the weight of the chain. In order to broach this dam, then, the power must be able to overcome: (1) The total weight of the chain lying on the crest and on the up-stream and down-stream

sides; (2) the friction of the chain on the up-stream and down-stream sides of the dam and the crest, supposing the bottom to be immovable; (3) the tensile strength of the chain; (4) the inertia of the loose rock on the crest and as low down as the power is applied; (5) the friction of the loose rock pieces on each other; (6) the friction of each chain link on each other.

Owing to its construction, the chain would not present a rigid resistance until all the links were set up to a hard bearing. Thus it would act as a cushion and would reduce greatly the effective force of the blow. The imparting force would first have to overcome the weight of the chain and its friction on the rock and on itself to draw it taut. Therefore, if 6 ft. of water should be flowing over the dam, at a velocity of 6 ft. per second, and if a mahogany log, 20 ft. in diameter and 60 ft. long, submerged 16 ft. deep, should strike the dam, the strength of the dam would be more than double the broaching force, even after allowing the chain a working strength of only 50% of the proof test. The friction of the chain on the rock is found by calculation to be four times greater than the whole force of the water and the log tending to overturn it; therefore the dam could not be deformed, but must remain a unit, and preserve its normal section.

Now, suppose the water to be running 15 ft. deep over the dam, and assume the mean direction of the current to be elevated 22° 30′ above the horizontal, and, disregarding the weight of the upper apron, which, however, will be firmly chained to the dam, and will exert a downward pull of 19 136 tons against any force tending to overturn the dam; then, constructing the parallelogram of forces, it is found that the resultant strikes inside the base, the ratio being 65 : 220, therefore the dam cannot be overturned; and the angle of the resultant is less than the angle of friction, therefore it cannot slide, even if it were not prevented by the earth walls of the trench in which it is embedded, and by the method of construction by which it is anchored firmly by the chains to the flanking walls.

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AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

UNIT COSTS OF WORK IN PROGRESS.

An Informal Discussion at the Annual Convention, May 21st, 1902.*

SUBJECT FOR DISCUSSION.

"Is it possible and desirable to keep accounts of cost of work in such a manner as to ascertain unit costs on each class of work?"

By Messrs. SANFORD E. THOMPSON, W. W. CUMMINGS and S. WHINERY.

Mr. Thompson. SANFORD E. THOMPSON, Assoc. M. Am. Soc. C. E. (by letter).—Too great stress cannot be laid upon the utter worthlessness of any system of cost-keeping records which does not describe in full the materials handled and the conditions under which the work is performed.

The writer calls to mind a large cost-sheet relating to an earth dam with a concrete core-wall and a masonry spillway, which was constructed under contract, for storage-basin purposes, by one of our large cities. The engineers for the city had kept carefully the cost of each division of the work, and the unit costs were calculated. The cost per cubic yard for hauling the earth was calculated very carefully, but no remarks were made upon the character of the material excavated or the length of the haul. The actual cost per cubic yard of the masonry was recorded, but no distinction was made between face work and rubble work. The same lack of data was found in all the other divisions of the sheet. The unit costs were, in other words, of no use whatever in estimating another job, unless the design and the condi-

* The discussion of this subject, on which no formal paper was presented, is continued from the August, 1902, *Proceedings*.

tions under which the work was to be constructed were practically identical. Mr. Thompson.

This is cited merely as an illustration of the numerous cases where time is wasted in making up records, which, while mathematically exact, give no results that can be used for the basis of estimates upon new work which is different and yet contains similar features.

In the annual reports of almost all city engineers there are tables of costs of pipe laying, paving, and other municipal work, which would be of considerable value to the profession if such details as depth of cut, character of materials, length of haul, and laborer's rate of wages per day were given.

The experience of the writer has been that to obtain unit costs of real value, either in factory cost-keeping or in engineering construction, careful observations, covering short periods of time but taken very accurately, with all the attendant conditions described fully, are of far greater value for future estimates than figures which cover a long period of time but are not itemized carefully and for which the work is not described accurately. Considerable experience and practice are necessary, in taking either indoor or outdoor records of times of short duration, to select average conditions, and to make sure that all the auxiliary operations of the work are included, and that sufficient allowances are made for the unavoidable delays occurring throughout the day.

W. W. Cummings, M. Am. Soc. C. E. (by letter).—The subject of "Unit Costs of Work" is worthy of much thought. The writer heartily agrees with Mr. Whinery that the knowledge of such units, as the work progresses, often leads to discoveries of want of proper management, or lack of previous knowledge of the difficulties to be met, which results in prompt discipline in the one case or more economical methods in the other, and which, without such a system, would not have been appreciated until it was too late to remedy the evils. Mr. Cummings.

In harmony with Mr. Churchill's observations, the writer has known of ordinary second-rate foremen who have been stimulated into producing results of a high order by the daily comparison of the costs of their work.

It seems as though the discussion of advisability and possibility might be extended into a synopsis of the methods of securing these units and the principles on which such methods are based.

In establishing a system of reports, as has been well said, the general outlines must depend on the character of the work in hand, but the underlying principles are the same in all cases. No one but a person who has struggled through the establishment of such a method can appreciate the amount of labor necessary to avoid the complication caused by too much detail, or the ambiguity of too little.

Mr. Cummings. Simplicity is the first requisite, both on account of the uneducated men on whom the engineer must depend to secure the first entries, and for the purpose of making the clerical labor a minimum. A great mistake is to aim at such accuracy in obtaining the first entries that the notes become complicated and confused. As Mr. Crowell has said, extreme accuracy is not necessary, nor is it desirable. With a little coaching, the foreman will use his judgment in charging the odd fractions of labor and material, so that the weekly average will be more nearly correct than if a large mass of detailed data were obtained.

One principle that is important is to have the divisions and subdivisions of the reports on the same general plan, so that, in the gradual combination of the diversified reports, it is only necessary to add the similar items from the different parts of the work and for the different days, weeks, months, etc., until the work is completed.

Another principle is to combine the statistics by "daily" totals, and "to date" totals, "grand totals," etc., so that the subdivision of costs is obtained at once and can be read at a glance.

In devising a system to apply these principles the engineer takes the items from which he made his estimate, and has a daily report card from each subdivision or foreman. On these cards the labor and tools are classified, and there are seven columns headed: Number of Men, Previous Amounts, Hours, Rate, Daily, To Date, and Remarks.

Each foreman enters the hours of labor and the material for his section for the day. His section comprises, if possible, a certain condition of work. The time-keeper fills out the "Previous," "Daily" and "To Date" columns, and, under "Remarks," gives the qualifying conditions.

The cards are sent to the office, together with the engineer's reports of the "daily" and "to date" work done in the corresponding classes. The book-keeper enters the totals, from the foremen working under similar conditions, on a page ruled into sections of three columns each and having a particular class of the work for the heading of each section. Each of the three columns is headed "Amount," "Rate" and "Total," respectively. On one side of the page is a column for dates and a wide column for subdivided headings, while on the other side of the page is a wide column for remarks. This page is headed like the different foremen's cards, and can be used for daily, weekly, monthly or yearly reports by simply transcribing the totals.

The writer has used such a system for a number of years, and has been agreeably surprised at the ease with which the foremen take up the idea, and the small clerical force necessary to keep the records up to date. He recalls one time when 1 500 men were employed on a line extending over 12 miles, and the entire force consisted of three division engineers with one and two assistants each, three time-

keepers, one paymaster and two book-keepers. At that time the daily records were complete for inspection by 12 o'clock the following day. Mr. Cummings.

S. WHINERY, M. Am. Soc. C. E. (by letter).—The discussion of this topic has been interesting and valuable, but not as full as the importance of the subject merits. Mr. Whinery.

If some member of the Society, who has given the subject attention and has had considerable experience in devising and applying cost-keeping systems on engineering works, would favor the Society with a paper upon the subject, going into details and illustrations, he would render a substantial service to the Profession.

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AMERICAN SOCIETY OF CIVIL ENGINEERS.
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PAPERS AND DISCUSSIONS.

RELATIVE PERMANENCE OF STEEL AND MASONRY CONSTRUCTION.

An Informal Discussion at the Annual Convention, May 21st, 1902.*

SUBJECT FOR DISCUSSION.

"Is steel susceptible of being made as permanent a building material as masonry?"

By CHARLES G. DARRACH, M. Am. Soc. C. E.

Mr. Darrach. CHARLES G. DARRACH, M. Am. Soc. C. E. (by letter).—It is gratifying that upon so important a subject as that under discussion there should be, practically, unanimity of opinion. It would seem that, from the present knowledge of the art, composite construction will receive greater attention than heretofore.

As indicated in the opening remarks, and although in a degree criticised, the uncertainty of calculations, based upon general knowledge, should warn every engineer that failure may result unless special attention is given to, and tests made of, the particular quality of the materials used and the method of manipulation and construction. That the greatest economy can be obtained by composite construction (procuring the tensile values of metal with the compressive and protective values of the artificial stone), both as to first cost and cost of maintenance, seems to be the opinion of those entering into the discussion.

* The discussion of this subject, on which no formal paper was presented, is continued from the September, 1902, *Proceedings*.

There are two points, however, which seem to have been either overlooked or misapprehended: First, the necessity of protection against electrolysis; and second, that metal is not affected by pure water containing no air. In reference to the latter, it is doubtful whether any engineer ever has to deal with such water. The writer, at least, has not been fortunate enough to have to deal with water containing no air. In his long experience he has not found perfectly pure natural water without air. All natural waters contain air. Clear water, as found in Nature, has a greater erosive tendency than either muddy water or sewage. Mr. Darrach.

Water carrying suspended matter deposits it upon the conduits through which it passes, or upon the surfaces with which it comes in contact, and a part of this suspended matter forms a protective coating on the metal and deters corrosion.

In this discussion several cases have been cited in which metal has laid in silt, under several feet of water, for a long period without corrosion; nor are these results surprising; for, those who have had experience in designing and operating filters know well that with muddy waters, or sewage containing sludge, it takes but a short time and an exceedingly thin film to prevent absolutely the percolation of water through a sand bed.

The Society is to be congratulated upon the very free and intelligent discussion upon this most important subject, and, no doubt, it will be of great benefit to others than those of our own Society.

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PAPERS AND DISCUSSIONS.

IMPROVEMENT OF THE BLACK WARRIOR, WARRIOR AND TOMBIGBEE RIVERS, IN ALABAMA.

Discussion.*

By Messrs. George T. Nelles, Edward P. North, S. Whinery, George W. Rafter and Theodore Belzner.

Mr. Nelles. George T. Nelles, M. Am. Soc. C. E. (by letter).—During a connection of six years with the improvement of the Tennessee River and its principal tributaries, the writer had occasion to make a very comprehensive study of the improvement of non-tidal rivers in general, and to design and execute works of improvement very similar in their character and object to those described by Mr. McCalla; he, therefore, takes great pleasure in discussing the paper, and extends his discussion to the question of lock designs in general.

Method.—The improvement of rivers of this class can generally be effected either by regulation or canalization. The former method comprises the removal of obstructions, the rectification of the channel and the equalization of the slope and depth by means of excavation, training and contracting works. A review of many existing examples shows that the success of regulation works, where the flow is ample and the natural conditions not incompatible, depends upon their design and execution in accordance with correct hydrotechnic principles, upon the stability of the bed and bank, whether natural or

* Continued from the September, 1902, *Proceedings*. See April, 1902, *Proceedings*, for paper on this subject by R. C. McCalla, M. Am. Soc. C. E.

produced by artificial means, and upon the conservation to the greatest possible extent of the natural shape, conditions and tendencies of the stream. Mr. Nelles.

An improvement by canalization, depending upon the natural conditions, can be effected: By the construction of canals with proper locks around the obstructed sections; by the construction of locks and dams, either fixed or movable, in the bed of the river, so disposed as to produce the desired depths; or by a combination of these methods. Considered simply as a means of improvement, canalization is a much more certain and satisfactory method than regulation for streams of comparatively small flow and protracted low-water periods.*

The method adopted for the improvement of the Warrior system appears to be admirably suited for the conditions and requirements, for, in addition to the reasons given for the adoption of this method of improvement, it can be shown, by the application of the usual hydraulic formulas, that a low-water flow of not less than 2 500 cu. ft. per second would be necessary in order to secure anything like the same results by regulation methods.

Fixed or Movable Dams.—The question of using fixed or movable dams no doubt received the consideration its importance demands, and the conclusion reached, to use fixed dams, was doubtless fully justified; still, it appears to the writer, from the information furnished by the paper, that this question is at least open to argument. With fixed dams, it is extremely doubtful, in a river characterized by rapid rises of such short duration, if there will be any open-river navigation at all; that is, it will not be practicable for boats to take advantage of the high-water periods, and increase correspondingly the size and draft of their tows, so that, as a result, the size of the locks and the depth on the miter sills will be the limiting features of the commerce of the river. Consequently, if, as the author states, movable dams would add three months to the season of open-river navigation, it appears that the additional cost of construction and for maintenance would be fully justified, because the capacity of the streams would be increased sufficiently thereby to offset fully any reasonable difference in the original cost or for maintenance.

It is not thought by the writer that the leakage or loss of available

* For a more complete discussion of the question of improving non-tidal rivers, and the methods recommended for effecting such improvement in special cases, the reader is referred to the following published reports by the writer:

	House Document.	Congress.	Session.
The Improvement of the French Broad River, Tenn.	No. 616.	56th.	1st.
The Improvement of the Mountain Section, Tennessee River	" 461.	56th.	1st.
The Improvement of the Little Tennessee River, Tenn.	" 66.	56th.	2d.
The Improvement of the Clinch River, Tenn.	" 75.	56th.	2d.
The Improvement of the Hiwasee River, Tenn.	" 77.	56th.	2d.
The Improvement of the Holston River, Tenn.	" 218.	56th.	2d.
The Improvement of the Middle Tennessee River	" 50.	57th.	1st.

Mr. Nelles. water would be materially greater with movable dams than with the timber crib dams proposed. It has been shown by B. F. Thomas, M. Am. Soc. C. E.,* that it was possible at the needle dam in the Big Sandy River at Louisa, Ky., to reduce the leakage through the navigable pass, under a head of 12 ft., to less than 5½ cu. ft. per second, or less than 0.04 cu. ft. per second per linear foot of dam. In view of the comparatively small low-water flow in the Big Sandy River (50 cu. ft. per second) this loss would be of much greater relative importance in that case than a much greater loss in the case under consideration. The successful use of movable dams on the Kanawha and Big Sandy Rivers, and on the Meuse and other European streams, of far less low-water discharge than the Warrior, indicates clearly that leakage would not prove as serious a difficulty in the present case as anticipated by the author.

Stability of the Walls.—From an examination of the text and accompanying cuts (which, in the opinion of the writer, have been so reduced, condensed and abbreviated for publication that their usefulness has been materially impaired), it is not evident that the effect of submergence and upward pressure on the base has been considered in the design of the lock walls; doubtless, these features received consideration, but, to what extent, and how their effect has been provided for, is not made clear in the paper. Under ordinary circumstances, it is customary, in the design of retaining walls or dams, subject to water pressure, and founded on solid rock or other impervious strata, to neglect the effect of submergence and upward pressure on the base, on the supposition that by careful workmanship these effects can be reduced so that they need not be taken into consideration. Eminent authorities are arrayed on both sides of this question. In a paper entitled "High Walls or Dams to Resist the Pressure of Water,"† by the late James B. Francis, Past-President, Am. Soc. C. E., occurs the following:

"Most ledges of rock have seams in various directions which admit the passage of water. If such is the case with the rock on which the wall we are considering is built, we must assume that the water in the seams is in communication with the water in the reservoir, and that near (the back edge of the wall there) is an upward pressure on the masonry equal to the head. * * * The upward pressure may also extend over the whole base of the dam, naturally diminishing toward the toe, * * * where it would be zero. Supposing it to diminish uniformly from (the back to the toe), the average would be equal to that due to half the head. * * * The center of the upward pressure will be at * * * one-third of the width of the base from (the back edge). * * *

"It is often the case that in order to reach a suitable rock foundation a considerable part of the height of the wall is below the permanent

* Annual Report of Chief of Engineers, U. S. A., 1898, p. 2146.

† *Transactions*, Am. Soc. C. E., Vol. xix, p. 147.

level of the water in the ground. In this part of the wall the effective weight per cubic foot of the masonry is only its excess above the weight of a cubic foot of water." Mr. Nelles.

In a paper entitled "Notes on High Masonry Dams,"* by John D. Van Buren, M. Am. Soc. C. E., a strong argument is advanced in favor of designing dams to resist the probable upward pressure on the base.

In discussing these papers, Edward Wegmann, M. Am. Soc. C. E., denies the necessity for providing against the upward pressure, other than by careful workmanship, but admits that if the water should penetrate between the foundation and the base it would doubtless give rise to an upward pressure and diminish the stability of the wall.

Joseph P. Frizell, M. Am. Soc. C. E., says:

"Engineers of standing have affirmed that in computing the stability of cement masonry under water, when it is bedded on firm rock, the buoyancy of the mass should not be considered, the water being excluded from the bottom by the mortar. These experiments (by Mr. Francis) show that such exclusion is impossible."

E. Sherman Gould, M. Am. Soc. C. E., says:

"I think it may be doubted if the concluding paragraph of Mr. Francis' paper, regarding the loss of weight of foundations carried below the permanent level of water, is to be taken as an unquestioned fact. It would of course be safest, in such cases, to make calculations on both assumptions, and take the result which indicated the heaviest work."

E. A. Fuertes, M. Am. Soc. C. E., says:

"But it cannot be admitted as a certainty that 'an upward pressure may be transmitted through the mortar to the entire base' of the dam, for such a pressure could be transmitted only when the entire base is lifted from its support; and in this case no pressure could be exerted on the bed of the foundation. So long as the specific gravity of the material of the dam exceeds that of the water under the ordinary conditions of dams, direct contact and pressure must exist at many points of the base, however irregularly distributed or restricted they may be to small and unconnected areas. This fact points to the necessity of providing for increased surfaces, to diminish the probability of overloading the points of contact, thus increasing the probability of making them more numerous."

A paper,† descriptive of certain experiments by Messrs. Broenniman and Ross, shows clearly the existence of hydrostatic pressure in masonry of almost every description when subject to a head of water. The effect of this permeability on homogeneous structures and foundations is not set forth clearly in this paper or in the paper by Mr. Francis. It is generally conceded, however, that the stability of the wall is to some extent decreased.

* *Transactions*, Am. Soc. C. E., Vol. xxxiv, p. 493.

† *Journal* of the Western Society of Engineers, Vol. ii, p. 449.

Mr. Nelles. In his "Practical Designing of Retaining Walls," William Cain, M. Am. Soc. C. E., writes as follows:

> "As water often saturates the filling, and perhaps gets under the wall, we must consider, in certain cases, water pressure in connection with the thrust of the backing. * * * If the wall is founded on a porous stratum, the weight of masonry is similarly reduced (when submerged) by 62.4 lbs. per cubic foot, or, say one-half, ordinarily; but if the foundation is rock or good clay 'there is no more reason why water should get under the wall than that it should creep through any stratum of well constructed masonry or puddle dam,' as Mr. Baker has observed."

From a review of the authorities quoted, and others, it is seen that, however much engineers may differ in regard to the effect of submergence and upward pressure on walls resting on an impermeable foundation, they are practically in accord as to the necessity for considering their effect when the foundation is permeable.

In the case under consideration, where the walls are all founded on a permeable stratum of sand or gravel, and are dependent entirely upon two rows of sheet-piling to cut off the water, there seems to be no room (whenever there is a head of water) to doubt the existence of an upward pressure on the base, and these designs have recognized the existence of such a pressure by providing openings through the wooden floor to relieve it.

Testing the stability of the river wall (Section F–F, Fig. 6), for a head of water of 17 ft. on the outside, when the lock chamber is empty, considering the upward water pressure on the base and the downward as well as the horizontal water pressure on the back, and assuming the wall to be 30 ft. high, 6 ft. wide on top and 12.25 ft. wide on the base, with sloping back, it is found that, for a weight of 140 lbs. per cubic foot for the masonry, the factor of safety against overturning is 2, instead of 6, as stated by the author, and that the center of pressure falls about 1.25 ft. beyond the outer limit of the middle third of the base, or at about the inner limit of the outer fifth of the base. According to Trautwine and others, these are safe conditions for well-constructed retaining walls, but, according to the generally accepted conditions of stability, *viz.*, that the center of pressure shall fall within the middle third of the base, and the factor of safety against overturning shall not be less than 3 for walls of this description, subject to water pressure and to sudden shocks and jars, it appears that a sufficient margin of safety has not been provided.

It is the writer's opinion that a much more trying condition of pressure against this wall will be found to exist during floods, when the lock is nearly full of water and the pressure is outward. The data are not given for an exact determination of this question, but, assuming the difference in level, at the time the walls are flooded, to be 2.5 ft., and that this difference increases proportionately up to

10 ft. as the river falls, and calculating the stability of the wall for the various changes in the pool levels, it is found that the most trying condition of pressure will exist when the water level in the lock is at Elevation 99 and in the river at Elevation 93.8. For this condition it is found that the factor of safety against overturning is only 1.64, and that the center of pressure is about 1.35 ft. beyond the outer limit of the middle third of the base. If the actual cross-section of the wall is used in calculating its stability, thus increasing the head of water by 1 ft. and the width of the base by 2 ft., it is found, for the conditions of pressure above stated, that in both cases the factors of stability will be less than shown by the preceding calculations. Mr. Nelles.

From these considerations it appears that this wall is safe, although the factors for the most trying conditions of pressure are not as great as the best practice demands for walls subject to shocks or jars from any cause, or where great interests would be jeopardized by a failure.

Testing the stability of the land wall, which is taken as 30 ft. high, 6 ft. wide on top and 16 ft. wide on the base, with five 2-ft. steps on the back (Section F-F, Fig. 6), for the case where the lock is empty and the head of water behind the wall is 17 ft., assuming, as is the general practice, that the wall will be called upon to resist the combined action of the earth and water pressures, estimated separately, and, in addition, an upward pressure on the base due to the head of 17 ft., and calculating the earth pressure by the Rankine formula, using a natural earth slope of 30° and a weight of 120 lbs. per cubic foot, it is found that the factor against overturning is 1.6, and that the center of pressure falls 2.3 ft. beyond the outer limit of the middle third of the base. For earth pressure alone the factor against overturning is 2.8, and the center of pressure falls close to the outer limit of the middle third of the base.

The writer has frequently had occasion to test the stability of gate abutment walls, and has found almost invariably that the dimensions of such walls as fixed by a consideration of the room required for operating machinery and for culverts, provided ample weight and stability to resist safely the external forces acting on them. In the present case, taking the lower river abutment, and assuming a length of 30 ft. to resist the thrust of the gate, for the condition of pressure for which the river wall was tested, *i. e.*, water in the lock chamber at Elevation 99, and outside the chamber at Elevation 93.8, it is found that the factor against overturning is 3 and against sliding is nearly 4.

Sill Failures.—One of the most fruitful sources of accident to locks is found in the lifting or failure of the miter sills, due to insufficient weight or fastening. In this country, the most notable examples of accidents from this source that have come to the writer's notice are as follows:

At the Louisville and Portland Canal locks, in 1891, before the

Mr. Nelles. canal had been opened for traffic,* under a head of 9½ ft., the upper, middle and lower gate sills failed in rapid succession by lifting. The sills were composed of large blocks of stone, 6 x 6 x 2 ft., laid in cement mortar on bed-rock, but not bolted. After the accident it was discovered that the bed-rock was full of seams, and had been shattered badly in preparing it for the foundation. The repairs were made quickly and successfully by bolting the sill stones to the bed-rock with 2-in. fox-wedged bolts of considerable length.

At the Des Moines Rapids Canal, in 1877, after having been in operation for one month, it was discovered that the coping courses of the lift walls and the lower sills of the middle and lower locks had lifted from 1 to 3 ins., under the pressure due to a head of 11 ft. When the locks were pumped out for repairs it was found that the primary cause of the failure was the imperfect loading of the holding-down bolts. The sills of all the locks on this canal were immediately strengthened and repaired by means of 1¾-in. fox-wedged bolts, extending well down into the bed-rock, and, while the bolts were still hot, the holes were poured full of melted sulphur. It is understood that these repairs were effective, and that no further trouble has been experienced from this cause.†

At the new 800-ft. lock at Sault Ste. Marie, in September, 1895, before the lock was opened to navigation, it was found that the coping of the upper guard gate miter sill rose 2½ ins. under the pressure due to a head of 14½ ft. of water. No reason is given for the failure, and the damage was immediately repaired by re-setting the stones and making them fast with one hundred 1½-in. fox-wedged bolts, set in rich mortar. The other sills at this lock were also re-bolted and made much more secure than was originally thought necessary.‡ Considerable difficulty was also experienced at this lock by reason of the lifting of the floor and culvert timbers when under pressure. This difficulty was remedied by the use of 1½-in. fox-wedged bolts of proper length. In connection with these repairs, a great many tests and experiments were made to determine the holding power of anchor bolts set in cement mortar.§ The results of these tests may be stated briefly as follows: The adhesion of 1 to 1 Portland cement mortar to hammered bar-iron varied from 42 to 152 lbs. per square inch, in six months. The adhesion of 1 to 2 Portland cement mortar to 1-in. round iron rods, imbedded from 1 to 9 ins., varied from 230 to 350 lbs. per square inch, in one month. Tests made with limestone screenings instead of sand in the mortar gave results nearly double those above stated. The tests made seem to indicate that the adhesion per square inch is independent of the area in contact, whether due to the depth imbedded or to the size of the rods.

* Annual Report of Chief of Engineers, U. S. A., 1872, p. 460.
† Annual Report of Chief of Engineers, U. S. A., 1877, p. 786.
‡ Annual Report of Chief of Engineers, U. S. A., 1896, p. 2787.
§ Annual Report of Chief of Engineers, U. S. A., 1895, p. 2917.

At the Muscle Shoals Canal, in Northern Alabama, the same trouble was found at all the locks where the lift exceeded 8 ft. The sill stones are generally 6 x 6 ft., and 2.5 ft. thick, set in mortar on bed-rock and partially bolted. No serious accidents have ever resulted at these locks from this cause, and the repairs have been effected by re-bolting the disturbed sill stones and grouting with rich mortar. Mr. Nelles.

In view of these somewhat general defects in lock design or construction, the writer is of the opinion that some special provision, not indicated on the plans, will be necessary to assure the safety of the gate and coffer-dam sills in the design now under discussion.

Gates, Valves and Culverts.—The adoption of the methods advanced by the United States Deep Waterways Commission in the design of these gates should make them an example of the most advanced ideas in structures of this kind, and it is to be regretted that the author has not gone deeper into the details of the design, and given the dimensions, conditions of pressure and size of parts on the drawings. The method of operation and the details of the gates have been worked out in a highly ingenious manner.

The exact design of the gates for locks of this description, where the conditions of pressure are constantly changing, is much more difficult and complicated than the design of gates where the pressure conditions can be considered constant, as for instance in the case of the Deep Waterways Commission locks. In cases like the present one, where the pool levels are constantly changing with the stage of the river, each part should be designed especially for the most trying condition of pressure that can come on it, and it is not unusual to find that this condition is different for each member in the gate; consequently, it is not possible to design such a gate with reference to its rigidity, as advocated by Captain Hodges in his work on "Mitering Lock Gates," but rather with reference to a given unit stress under the maximum load.

The variation between the actual and theoretical stress in lock gates, as determined by the usual methods of calculation and the effect of the vertical members in distributing the stress through the gate, is well illustrated by certain observations made in 1898 by Sydney B. Williamson, M. Am. Soc. C. E., at Lock 6 of the Muscle Shoals Canal. These observations consisted in measuring the actual deflection of the horizontal girders in the lower gate at Lock 6, with the lock full and the lower pool empty. This gate is made up of 15-in. 53-lb., rolled I-beams, 34.6 ft. long, for horizontal girders, spaced as shown in Table No. 8. The gate is sheathed on the up-stream side with ¼-in. plates, which extend in unbroken sheets from top to bottom of the gate, with ¼ x 12-in. cover plates at all joints, and is stiffened by means of four diagonal 9-in. I-beams, weighing 25 lbs. per foot, arranged in the form of an inverted W riveted on the back of the

Mr. Nelles. gate. The quoin and miter posts are fastened to the sheathing and upstream flange of the horizontal girders in such a manner that they all act together.

TABLE No. 8.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Feet.	Pounds.	Pounds.	Inches.	Inches.	Pounds.	Pounds.
0.21	80	808	0.07	0.56	6 315	234
4.22	880	23 725	2.10	0.94	10 60C	393
6.86	1 210	32 622	2.892	1.125	12 686	470
9.85	1 670	45 024	3.992	1.125	12 686	470
12.29	1 825	49 208	4 363	1.06	11 953	443
14.60	2 060	55 539	4.925	0.75	8 457	313
16.81	2 220	59 858	5.307	0.68	7 104	263
17.81	Top of	sill.				
18.62	1 480	38 554	Bottom of	gate.		

Table No. 8 shows: (1) the head of water on the horizontal girders, *i. e.*, the depth of the girders below the level of the upper pool; (2) the load per linear foot on each horizontal girder, calculated on the assumption that the gate has no vertical rigidity, and that the pressure on the sheathing due to the head is transmitted to the nearest horizontal girder; (3) the corresponding maximum unit stress in the horizontal girders, on the supposition that they carry all the pressure, and neglecting the effect of the thrust in the horizontal girders; (4) the calculated maximum deflection corresponding to the maximum unit stress given in Column 3; (5) the actual measured deflection of the horizontal girders; (6) the calculated maximum unit stress corresponding to the measured deflection, neglecting the effect of the trust in the horizontals, and assuming that the girders receive no assistance from the sheathing; (7) the calculated load per linear foot corresponding to the deflection and unit stress given in Columns 5 and 6.

Under the usual assumptions and methods of calculating the stress in gates of this kind, it appears from Column 3 that this gate is absolutely unsafe, and is strained beyond the elastic limit, yet the measured deflections and the actual condition of the gate show that such is not the case.

By assuming the sheathing to act with the compression flange of the horizontal girders, and the compression due to thrust in the girders to offset the excessive tension in the other flange, the calculated stress can be reduced to safe limits; but it is not possible, by any reasonable assumption, to reduce the calculated stress to the figures corresponding to the measured deflection.

Power to Maneuver Lock Gates.—The resistance to be overcome in maneuvering lock gates is made up of the frictional resistance of the bearings, the wind pressure against the exposed surface of the gate,

and the resistance due to the dynamic pressure of the water. All of these resistances can be calculated with reasonable certainty for given conditions. Under conditions requiring the operations of the lock gates while the wind is blowing 15 miles or more per hour, it is usually found that this is a source of far the greatest resistance to be overcome, and that machinery designed to overcome the resistance due to wind pressure will be more than sufficient under all ordinary circumstances. Mr. Nelles.

In the study of the power plant for the lift lock of the Colbert Shoals Canal, the writer found the probable maximum force required to maneuver the gates to be made up as follows:

Dynamic resistance........................	15 per cent.
Wind resistance (30 miles per hour)..........	75 "
Frictional resistance........................	10 "

The actual power required depends upon the method of application, the character of the bearings and contact surfaces, and the time allowed for the operation, and may vary from that exerted by one man through simple and inexpensive appliances to 40 and 50 H.-P. exerted through expensive and complicated steam, hydraulic or electric motors.

At the Canadian "Soo" Lock, one 25-H.-P. electric motor is provided for each 37 x 40-ft. gate leaf, and one similar motor for each pair of 8 x 8-ft. butterfly valves.

At the American "Soo" Lock, a total of 150 H.-P. is provided to operate the hydraulic motors for four 40 x 50-ft. gate leaves and four 8 x 10-ft. culvert valves.

At the Cascade Locks, Ore., where the machinery is operated by direct water pressure, it was found that an actual expenditure of 10, H.-P. was necessary to open one 40 x 50-ft. leaf weighing 125 tons. and under ordinary circumstances; and the opening of the 10 x 10-ft. culvert valves required an expenditure of 18 H.-P.

The gates at Lock "A" of the Muscle Shoals Canal are operated by special hydraulic engines of unusual form and construction. In these engines the water pressure is applied against the sides of a small vane or fin, 9 x 18 ins., fastened to the quoin post in the extension of the axis of the gates, and working in a fan-shaped box arranged so as to allow the application of the pressure on either side of the vane.

The lower gates are 18 x 37 ft., and, when the wind is not high, can be opened and closed in 1½ minutes under 70 lbs. pump pressure. Under less favorable circumstances a pressure of 150 lbs. is often required to start the gates. This appliance has not proved perfectly satisfactory on account of the frequent breakage of the operating vane or fin.*

* Illustrations, showing the details of these engines, may be found in the Annual Report of the Chief of Engineers, U. S. A., 1890, sheet 111, p. 2126.

Mr. Nelles. *Culverts.*—The considerations bearing on the designs of culverts for filling and emptying locks are quite fully set forth in the recent report of the United States Deep Waterways Commission, and in that report reference is made to the wide variation in the coefficient of discharge through lock culverts, due to the shape and design of culverts.

Table No. 9 shows some rather crude observations, made at the Muscle Shoals Canal, which are of some interest and value in this connection, and gives the coefficient of discharge, for both filling and emptying locks of the usual workmanship, through culverts designed without special reference to ease of flow.

TABLE NO. 9.

Lock number.	Horizontal area of locks.	Lift of locks.	Time to fill locks.	Time to empty locks.	Area of culverts.	Coefficient while filling locks.	Coefficient while emptying locks.
	Square feet.	Feet.	Seconds.		Square feet.		
1.......	18 216	3.35	300	300	44.56	62.2	62.2
2.......	18 216	7.2	420	480	38.72	74.9	65.5
3.......	17 672	11.4	540	720	40	68.9	51.6
4.......	17 676	10.85	600	540	40	58.4	64.9
5.......	17 974	11.8	600	540	44.56	57.6	64
6.......	17 960	12	660	480	44.56	52.8	72.5
7.......	17 980	11.6	540	450	44.56	63.5	76.2
8.......	17 980	9.8	450	480	44.56	70	65.6
9.......	18 118	6.3	300	360	44.56	86.8	70.7

The time given in the table begins with the opening of the culvert valves and ends when the gates could be freely opened.

All of these locks, except Nos. 2 and 3, have two short filling and emptying culverts, about 4 x 6 ft., built in the gate abutments around the gates. Locks 2 and 3 have single 6 x 8-ft. culverts. The valves in the culverts reduce the area to that given in the table.

Size and Capacity of the Locks.—At first sight it seems that the locks are of insufficient size (52 x 282 ft.), to accommodate a large traffic, but, by an analysis of the conditions and methods, it can be shown that, under favorable circumstances, the system will have a sufficient capacity to handle between 8 000 000 and 10 000 000 tons of coal down stream per annum, in addition to carrying the empty barges back and taking care of the probable inland commerce. This is more than the present coal traffic on the Mississippi River, and is probably more than the Warrior system will be called on to carry for a great many years, and possibly more than the North Alabama coal fields will be able to produce.

Mr. Nelles. In conclusion, the writer wishes to disclaim all intention to criticize the improvement or designs described by the author, but offers these remarks simply as a discussion of the questions opened up by the paper.

Mr. North. EDWARD P. NORTH, M. Am. Soc. C. E.—Neglecting the technical portion of Mr. McCalla's valuable and interesting paper, and turning attention to the economic questions developed, occasion is taken to reiterate the opinion that unless a waterway is improved in such a manner as to pass boats of a burden at least equal to that of freight trains on parallel railroads, such an improvement will fail of its full economic service. In other words, the improvement of a watercourse may be of doubtful value unless it is on so ample a scale as to develop new industries and sources of freight by offering such low rates for transportation that commodities otherwise unsalable can be produced and brought to market with profit.

Through such a service consumers receive a double benefit in the reduction in price, due both to increased supply and the reduction in cost of transportation; much labor and capital is profitably utilized in production that would otherwise be idle, and railroads find their traffic and profits augmented by increased receipts from passengers and package freights. A smaller waterway, however, may be valuable in reducing freight rates on competing railroads, as set forth in reference to the Erie Canal by the late Albert Fink, Past-President, Am. Soc. C. E. But any such reduction, advantageous as it may be for producers and consumers, may be made to the loss of net income by the railroad, unless it is so radical as to develop new industries.

The history of the traffic through and past the "Soo" may be as instructive as to the value of large channels for transportation as any known. The last report of Colonel G. J. Lydecker, on "Lake Commerce Passing through Canals at Sault Ste. Marie, Michigan and Ontario, for 1901," gives data from which Table No. 10 has been made.

TABLE No. 10.—"Soo" TRAFFIC.

Year.	Tons of freight.	Aggregate value.	Value per ton.
1851................	12 600	1 675 000	$133.00
1861...	88 000	6 000 000	68.00
1871................	585 000	13 000 000	22.00
1881................	1 568 000	30 000 000	19.00
1891................	8 889 000	128 000 000	14.50
1901..........	28 403 065	289 916 865	10.21

That is, in 1851, without a canal, the produce of that country could not be brought to market unless its average value was $133. Fifty years later, with a canal, an average value of $10.21 brought more than 2 200 times as much freight to market.

Mr. North. It will be remembered that the canal was opened in 1855 with double-lift locks, having 11½ ft. on their miter-sills, built under charter from the State of Michigan. In 1881 a single-lift lock, with 17 ft. on its miter-sills, was built by the General Government. In 1895 the Canadian lock, with 20 ft. on its miter sills, was opened, and in 1896 another lock by the United States Government, known as the Poe lock, was opened to traffic, with 21 ft. on its miter-sills.

It will be noticed immediately that up to 1871 the canal was doing an immense and rapidly increasing service to the country by increasing the commodities brought to market and decreasing the cost at which they could be offered to consumers. But between 1871 and 1881 there was a marked slackening in the public value of the canal, both as to quantity carried and reduction in value of freight, followed, after the last-mentioned date, by an increasing value in its services. During the decade ending with 1881, or, more exactly, during its last half, the limiting depth of the miter-sills in the "State locks" prevented profitable competition with the railroads, and Lake commerce was diminishing. But opening the 17-ft. lock and the concurrent deepening of the Lake channels has resulted in the growth indicated.

This relation between traffic and the capacity of its channels is ably discussed in the "Report of the Committee on Canals of New York State, 1899," made to Governor, now President, Roosevelt. Commencing on page 196, it says:

"In 1875 the total tonnage on the lakes was nearly 600 000 tons. * * * The traffic, as estimated by entrances and clearances at American ports, was for that year about 15 000 000 tons.

"This development had, however, been secured without any material increase in the size of the vessels in use—a limit being placed on size by the depth of water in the harbors and in the channels connecting Lake Erie and Lake Superior with Lake Huron-Michigan. By 1875 the advance in railroad construction and management had reached a point which enabled the railroads to compete with the lake vessels; and when to this was added the railroad rate wars of the next few years there was not only a cessation of increase in lake commerce, but a positive decline both in equipment and traffic. New construction of vessels, which had reached as high as 73 000 tons in 1874, was only 7 000 tons in 1877, and averaged only 13 000 tons a year for the five years ending in 1880. In the latter year all the vessels on the lakes aggregated only 560 000 tons, 30 000 less than five years before.

"The beginning of the new decade marked a significant revival in lake commerce, which cannot be disconnected from the improvements in lake harbors and channels undertaken by the national government. The most important work brought to completion at this time was the opening of the ship canal with an 18-ft. draft, which took the place of the 10-ft. canal and locks maintained by the State of Michigan at Sault Ste. Marie."

Placing the depth at 10 ft. is an unfortunate misprint. On page 301 of the Report of the Chief of Engineers for 1881, we read:

"A depth of about 11 ft. 6 ins. could be carried through the channel between Lakes Superior and Huron when the Government

began its improvement in 1870 * * * to construct a new lock with a single lift of 18 ft. and a capacity of 515 x 80 ft., for a draught of 17 ft." Mr. North.

And it adds that, up to that time, the expenditures had only resulted in greater speed. In the same report for 1882, page 2358, Major Weitzel says that the conditions of the land grant, by the aid of which the State of Michigan built the canal, called for a depth of water of 12 ft., and he states that the canal had a depth of 12 ft. at mean stage.

Incidentally, Major Weitzel estimates a fair freight rate per ton-mile on iron ore through the State Canal as 2.8 mills. The average freight rate on all commodities returned for 1887 was 2.3 mills, and, with the facilities offered by enlarged channels, the average freight rates have been less than 1 mill, while the freight on iron ore for 1901 was 0.78 mill per ton-mile.

Continuing, the report, after calling attention to the increase, both of tonnage and in the size of vessels built, on the opening of the deeper lock, says:

"The increase of shipping was, of course, but the accompaniment of the increase of traffic. In 1885 the record of entrances and clearances at the United States ports on the lakes showed a traffic of 19 200 000 tons; by 1890 this had almost doubled, reaching the figure 37 500 000 tons, about 9 000 000 tons of which passed through the St. Mary's Falls canal. By 1896 the total traffic was 52 000 000 tons, and in 1898 62 500 000 tons, 18 000 000 tons passing through the St. Mary's Falls canal."

This is followed by an estimate of 60 000 000 tons as the total freight movement on the Lakes for 1898. Most of the figures given above are reiterated in diagrams and tables incorporated in the text of the report.

Increasing a decaying traffic of 15 000 000 tons in 1875 to 62 500 000 in 1898 is, as set forth in the report quoted, so plainly the result of increasing the maximum possible draft of vessels from 11½ to 17 and 20 ft. as to cause doubts if those calling for a 10-ft. navigation through New York State as improving its water routes "to the utmost limit of which it is capable," have ever seen the report of the Committee on Canals, or know that the Canadian canals, with 14 ft. on their miter-sills, have been unable to effect serviceable economies in transportation.

With the increase of freightage through the "Soo," the development of the country directly tributary to and feeding this route has been marked. Taking the "Upper Peninsula" of Michigan, Wisconsin, Minnesota and the Dakotas, the following figures are from census returns for the years named:

	1850.	1880.	1900.
Population............	317 013	2 315 477	4 802 585
Value of farms........	26 870 511	575 109 958	1 783 498 355

Mr. North. It cannot be claimed that all of this increase in population and farm values is due to the cheap transportation offered by the Lake route, though it will be readily admitted that it has been an important factor in the development of those States.

The development of our iron and steel industry, however, is universally admitted to be dependent on this water route. In 1855, the year the canal was opened, the Hon. A. S. Hewitt made a generally accepted estimate that the world's production of pig iron was 7 000 000 tons. Of this amount the United States contributed 700 159 tons, or 10 per cent. In that year 1 447 tons of iron ore were carried through the Canal. In 1880, 677 073 tons of iron ore passed through the lock at the "Soo"; the total production of pig iron is estimated at 17 950 000, and the United States contributed 3 835 191 tons, or 21.3% of the total. For 1900 Mr. Swank estimates the total production at 40 400 000 tons, of which the United States made 13 789 242 tons, or 34.1%, and that season 16 443 568 tons of ore went down the Lakes through the locks at the "Soo." And it seems reasonable to predict that if a convenient waterway between Duluth and New York Harbor, with 21 ft. depth, could be secured, as asked by the various Deep Waterways Conventions, within ten years the United States would be making fully 50% of the world's output of pig iron.

The service done to this country, and the world in general, by the decreased cost of iron due to our large production, which is made possible by the commodious and cheap transportation through the enlarged waterways of the Lakes, does not receive the full recognition that is its due. In 1872, when for the three preceding years our make had not averaged 1 700 000 tons, the price of pig iron was run up by unfeeling monopolists, on an increased demand, to $53.88 per ton for the month of September, averaging $48.88 for the year. Again, during the boom of 1880, when we made only 3 835 191 tons of pig iron, the demand for steel rails exceeded the supply, with an official price of $85 in February and an average of $67.50 for the year. This year, with our possible, if not probable, make of 18 000 000 tons, and the largest consumption of iron ever known, the published price of steel rails is $28, though more is paid for prompt delivery, and the high prices of the past are improbable unless our waterways are allowed to decay. There seems to be no ground for doubting that the improvement of the Lake channels has been of great service to the people of this United States in particular, and the world in general, by developing industries and creating new sources of supply. The only reason that the improvement should not be continued to greater depth seems to be that the value of capital invested in the boats now in use would be impaired by the lower freight rates at which larger boats could be profitably operated.

The value of improvements on the Mississippi River are not so unmistakable as those on the Lakes. This river is badly handicapped

by the fact that it has the least water in its channels during the season of the greatest freight offerings. On the other hand, it is nearly 80% longer than the aggregate of the routes from Chicago and Duluth to Buffalo and has 15 000 miles of navigable tributaries, most of which are shallow streams. But according to a paper* by J. A. Ockerson, M. Am. Soc. C. E., 8 ft. cannot be depended on, and there is a recorded depth of 3 ft. between St. Louis and Cairo. In high water, however, cargoes of 40 000 to 50 000 tons of coal are taken in a single tow from Louisville to New Orleans, "a distance of 1 400 miles, at a cost of about 10 cents per ton." Mr. North.

While Mr. Ockerson does not deal with all the traffic of the river, he gives a diagram showing the main features of the trade between St. Louis and New Orleans for the thirty years ending with 1900, and a very valuable table, commencing with 1865. This table shows that for the three years ending with 1867 the river freight on a bushel of wheat from St. Louis to New Orleans averaged 29.4 cents; and for the three years ending with 1900 the average was 4.42 cents. By rail, from St. Louis to New York, the average freight charge for the first mentioned period was 65.4, and for the last, 12.7 cents. By river the fall has been 85%, and by rail it has been 80.5 per cent. The percentage of river traffic to the whole grain traffic has varied from 0.31% in 1870, the first year in which it is given, to a maximum of 37.9% in 1881 and for 1900 it was 6.4 per cent. The percentages of wheat carried by river have been erratic. The decline in freight rates has been fairly uniform for both routes.

These reductions in freight rates, of course, have added materially to the wealth of the Mississippi Valley, and cheapened the merchandise carried to consumers. Some measure of this service to the Mississippi Valley may be gathered from the history of the Illinois Central Railroad, which was consolidated with the Chicago, St. Louis and New Orleans Railroad in 1882, making a through line from Chicago to New Orleans. In 1883 the freight traffic of the road was 604 632 667 ton-miles, carried at 1.43 cents. Since that date the Ohio has been bridged at Cairo, with many extensions and improvements of track, etc., showing well-founded commercial confidence in the future of the road and the country it serves. For 1900 the freight traffic of the road was 3 425 794 698 ton-miles, carried for 0.65 cent. Under a decrease of 54.5% in earnings per unit, the freight earnings increased from $3 463 648 to $22 280 420.

Either the Mississippi River, the rail route between St. Louis and New York, or the Illinois Central Railroad, or all of them, have evidently been of great value to production in that portion of the country they serve, and if any damage has been done to either interest by the lessened cost of transportation, the greater burden seems to have fallen on the River interest, which still seems strong enough to

* Read before the Engineers' Club of St. Louis, September 18th, 1901.

Mr. North. prevent any increase in freight rates, and possibly strong enough to force a continued decline.

There are two striking instances of insufficiently improved waterways, viz., the Erie Canal and the Tennessee River. When it was decided to build the Erie Canal, New York was a one-horse town, inferior in prestige and importance to either Charlestown, Philadelphia or Boston. Wise men at that time thought New London would be the principal seaport of the Union. From the opening of the Erie Canal, in 1825, until about 1880, its comparatively low freight rates and great volume of traffic made it an important factor in additions to our wealth. and caused all the railroads of the country to center at New York Harbor. But since 1862 its channel has not been enlarged. For twenty years competing freight trains have been carrying more than fully loaded boats. Though there is yet a slight reduction in grain rates when the canal opens, it is powerless to prevent discriminations against the Port of New York and the inhabitants of that city, and the interests of the State and country are so overshadowed by the influence of those who keep toll houses at its ends that no proposition to increase its navigable depth to more than 10 ft. seems to be entertained.

In the Tennessee River, the great obstacle to navigation is at and about the Muscle Shoals, where the river falls more than 100 ft. Some 16 miles of canal, with a steel trunk 900 ft. long and having a cross-section of 60 x 5 ft., and with locks 300 x 60 x 5 ft., was opened on November 10th, 1891, at a cost of slightly more than $3 000 000. In 1900 traffic had developed to such an extent that 14 881 tons of freight passed through the canal, at a cost of $65 546 for attendance and maintenance. This is $4.40 per ton, and, at the average railroad rate for that year, would have carried the freight nearly 600 miles. The unremunerative character of the improvement is due to the fact that no boat which can pass through the locks can float machinery enough to make it effective as either a freight carrier or a towboat. The Tennessee is nearly as long as the Ohio, and has the potentiality of nearly as great wealth.

Neither of these instances presents any argument against improving waterways. The Erie Canal, which once controlled the route of freight and the location of wealth by presenting the most ample and convenient channel for transportation, has fallen to its present low estate greatly through political and personal aspirations. The money expended on the Tennessee has been wasted, to a great extent, and the development of wealth in its valley seriously retarded by men of undoubted honesty, but possessed of inadequate knowledge of the transportation problem.

Mr. McCalla does not mention the tonnage of the boats that are expected to pass the locks on the improvement he describes, but it is possible that they will accommodate barges of from 1 800 to 2 000 tons, or about one-half of the probable competing train-load. The small

draft will prohibit distribution along the shores of the Gulf, without transferring cargoes, and, as the locks will only admit one boat at a time, fleet towing will be attended with considerable delay and expense, except on the lower fourth of the improvement. It would cheapen transportation materially if the three lower locks were lengthened so that tows could be made up for Mobile at Demopolis. As at present, it is questionable if the improvement is of sufficient capacity to develop new industries or serve the country by reductions in freight rates material enough to cause noticeable increase of wealth in the valley of the Warrior and Tombigbee Rivers. Mr. North.

Improvements in the mechanism and methods of railroad transportation have had, and will probably continue to have, so marked an influence on transportation by water that reference is made to the beneficence of our railroad development, a great deal of which has been forced on their managers by the competition of our free waterways, and most of which would have been impossible without the increased production and consumption due to the low transportation charges found profitable by both water routes and railroads.

In 1882 the editor of "Poor's Manual" succeeded for the first time in obtaining the ton-mileage and rates on all of our railroads. The figures for the two extreme dates available are:

	Ton-mileage, United States Railroads.	Rate per ton-mile.
1882	39 302 209 249	1.236 cents.
1900	141 162 109 413	0.746 cent.

This is an increase of 259% in service, with a decrease of 39.65% in compensation per unit. This is not as good a showing as is made by the Lake traffic, but, considering the volume moved, it is probably more efficient in wealth production.

A comparison of our results with those attained in the United Kingdom of Great Britain and Ireland is rendered difficult by the fact that the English do not return ton-mileage, but, as there is neither a free internal water route, a free harbor, nor any long canal of even the capacity of the Erie Canal in that country, a comparison is made in Table No. 11 on the basis of tons shipped.

TABLE No. 11.—Freight Shipments.

	Freight receipts.	Tons shipped.	Receipts per ton.
Railways of the United Kingdom.			
1882	£37 704 815	256 216 833	35.32 pence
1900	53 470 564	424 929 513	31.20 "
Railroads of the United States.			
1882	$485 778 881	360 490 375	$1.348
1900	1 052 885 811	1 071 481 919	0.983

Mr. North.

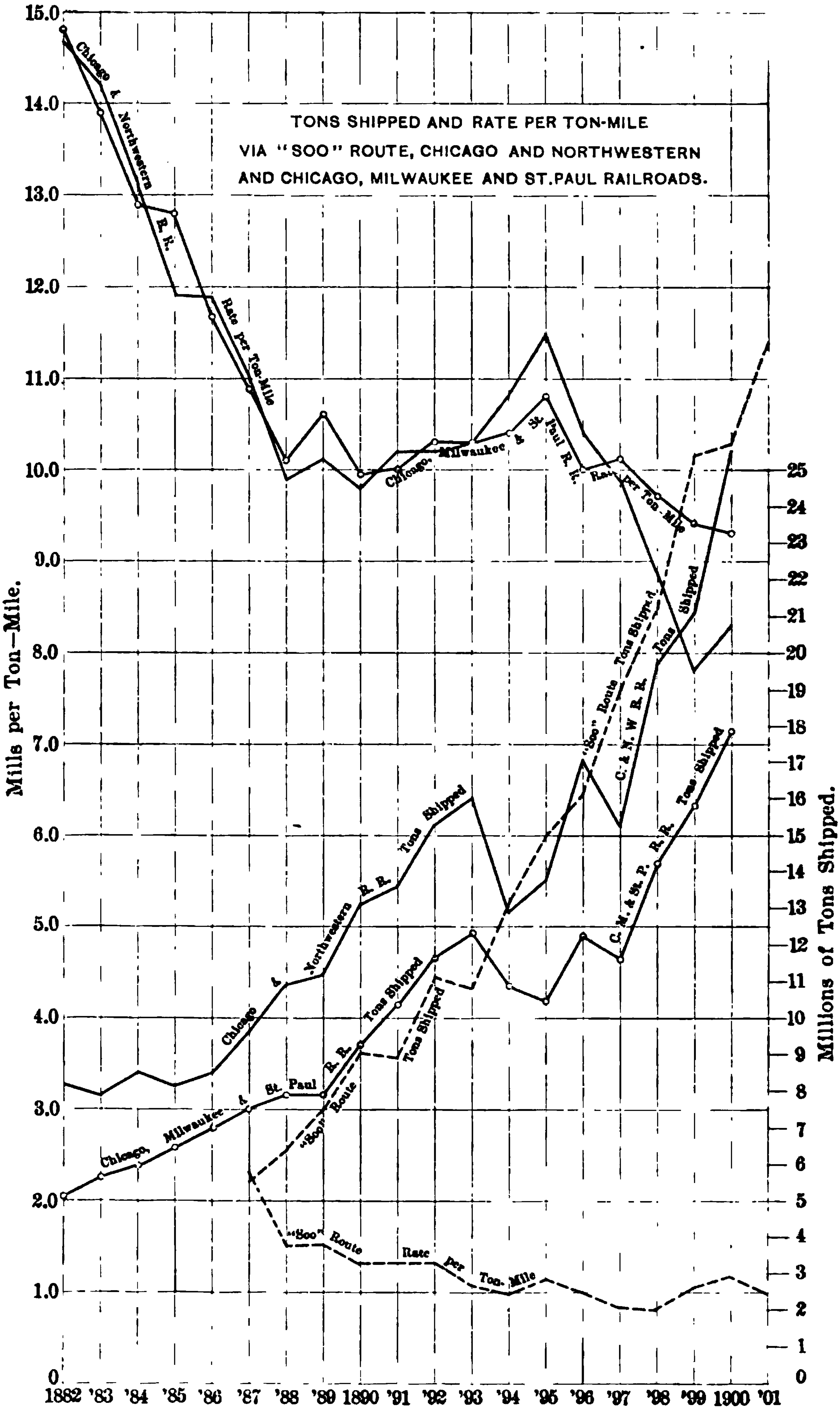

FIG. 32.

Mr. North.

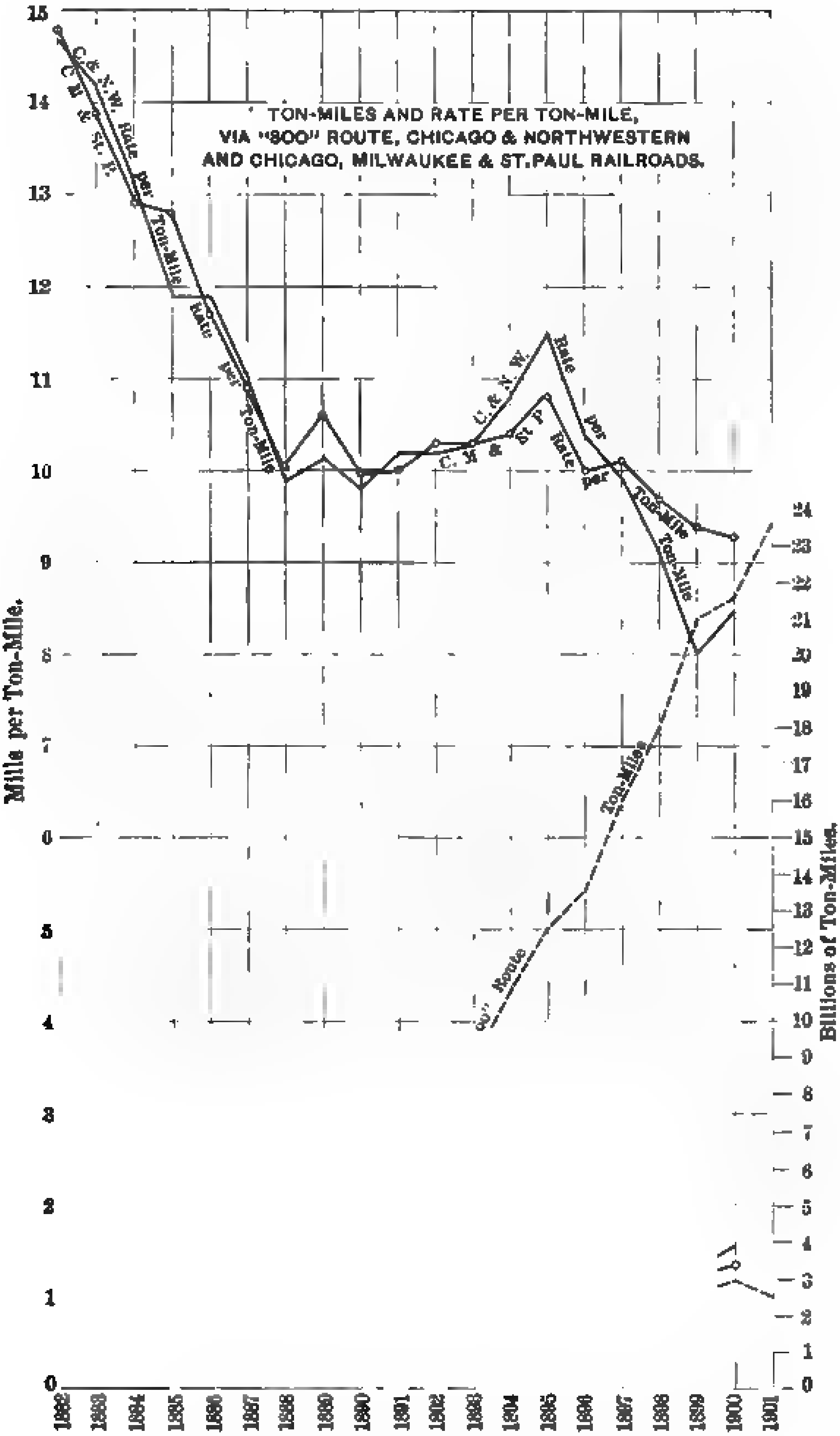

FIG. 88.

Mr. North. It is seen that, while the British managers have increased the tons shipped by approximately 66% and decreased the compensation by 12%, our managers have increased the tons shipped by 170% and decreased the charges per ton shipped by 27 per cent. One result of the more liberal policy in this country is shown in the following:

TONS SHIPPED PER CAPITA.

	Year.	Tons.	Year.	Tons.
United Kingdom	1882	7.28	1900	10.25
United States	1882	6.48	1900	14.05

That is to say, in 1882 the inhabitants of the United Kingdom shipped 6.4% more tons per capita than we, and in 1900 we shipped 37% more than they. Concurrently, the recognized value of our railroad securities as investments is changing places with those of the British. The comparison is not entirely satisfactory, as it is generally understood that for more than fifty years there has been no substantial reduction in British freight rates; J. S. Jeans saying, in his "Railway Problems," that any apparent reduction in English rates is due to shortened haul; but in this country the average haul has been increased by about 20 per cent.

Speaking of our reductions in freight rates, the learned author says:

"This colossal concession to the trade and industry of America has both immediate and far reaching consequences. Its more immediate effects have been to enable the remotest cattle-breeder and wheat-grower in the United States to obtain access to other markets than his own, and thereby to enter into the world's competition for the supply of the world's markets. Its ultimate results are to be witnessed in the extraordinary cheapness of the bread-stuffs furnished to England by the United States, and, as a necessary consequence thereof, by other countries; in the singularly severe and protracted depression of British agriculture; and in the complete discomfiture of many interests that were fairly strong and capable of holding their own until this fiscal monster came to the front."

There was for some years a remarkable parallelism between the capital put into American railroads and the decrease in the value of English farm lands. How far the early adoption of our traffic and fiscal policies by the British would have averted "the complete discomfiture of many interests that were fairly strong, etc.," until confronted by a superior intelligence, will never be known, but the complete discomfiture of large interests, through a narrow-minded and obstructive grasping for large gains, does not, on the whole, make for the general welfare, however just it may be for the obstructionists.

The effect of a capacious waterway on near-by railroads may be seen by comparing the route through the "Soo" with the Chicago and Northwestern, and the Chicago, Milwaukee and St. Paul Railroads.

Mr. North.

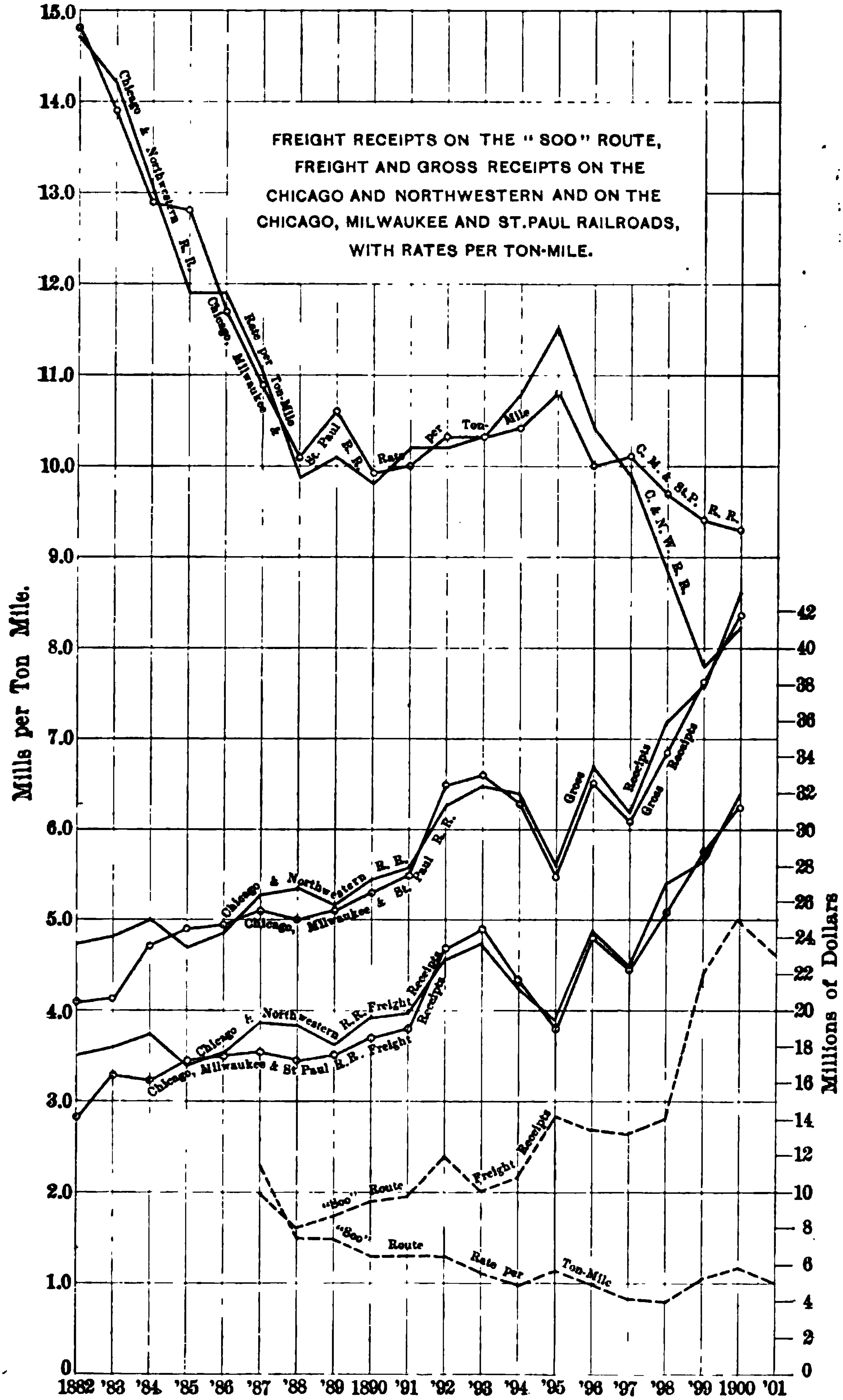

FIG. 34.

Mr. North. In 1901 the tonnage through the "Soo" was eighteen times that of 1881, and the average value per ton was between 53 and 54% of the value in 1881. No definite return of freights paid is known until 1887; then the average freight rate was 2.13 mills per ton-mile, and in 1901 the rate was 0.99 mill. The two railroads named, in a part of their lengths, compete with the "Soo" route, but through a large area they feed it and are fed by it. Commencing with 1882, the services they performed and the rates charged are given in Table No. 12.

TABLE No. 12.

FOR 1882.

C., M. & St. P. R. R.	945 250 159	ton-miles at	1.48 cents.
C. & N. W. R. R.	1 192 188 039	" "	1.47 "
	2 137 438 198	" "	1.475 "

FOR 1900.

C., M. & St. P. R. R.	3 857 456 584	ton-miles at	0.93 cent.
C. & N. W. R. R.	3 849 367 760	" "	0.83 "
	7 206 824 344	" "	0.873 "

Here the decrease in freight rates, though noticeable, is not as great as on the Lakes, nor is the increase in traffic as large. The increase in ton-mileage has not been quite up to the ratio of the whole country, and the rate charged has fallen a little faster than that ratio.

The effect of an average decline of 40%, in the charges made to the inhabitants of their territory for services rendered, on the value of the two roads, as shown by the market prices of their stocks on July 1st of the two years is shown in Table No 13.

It does not seem reasonable to claim the cheap transportation offered by the improved Lake route as the sole factor in the increased population and farm values in the States tributary to that route, nor can it be contended that the doubling of the value of these two great railroads would have been possible without the contributions to the wealth of the country made by the low freight rates on the Lakes. Both channels of distribution seem to have been mutually helpful.

The relations between the freight traffic, the receipts per unit, and the aggregate receipts, on the two roads mentioned and through the "Soo" are shown on the diagrams, Figs. 32, 33 and 34.

Attention should be called to the fact that, while the average haul on the railroads is about 160 miles, by the "Soo" it is more than 800 miles.

TABLE No. 13.—VALUE OF STOCKS ON THE C., M. & ST. P. AND THE C. & N. W. RAILROADS ON JULY 1ST, 1882 AND 1900. Mr. North.

JULY 1ST, 1882.

C., M. & St. P. R. R.	$27 904 261 Common, at 112	$31 252 772	
	16 447 483 Preferred, at 127⅝	20 989 702	$52 242 474
C. & N. W. R. R.	15 075 924 Common, at 131¼	$19 813 400	
	22 153 119 Preferred, at 146	32 348 554	52 156 954
	816 008 Shares, at 125.50		$104 399 428

JULY 1ST, 1900.

C., M. & St. P. R. R.	$47 146 600 Common, at 111	$52 332 726	
	40 454 900 Preferred, at 171¼	69 279 016	$121 611 742
C. & N. W. R. R.	39 114 231 Common, at 159⅛	$62 240 520	
	22 395 160 Preferred, at 196	42 894 514	105 135 034
	1 491 109 Shares, at 152.06		$226 746 776

As long as all charges for transportation must be taken in some ratio from the resources of both producer and consumer, and high freight rates are as inimical to the prosperity of a country as low rates of wages, the claim made by many railroad managers that reductions in freight charges are a gift to the public will be true, but it seems in the instances cited to be fully as much a gift to the railroads as to the community. On the other hand, the assertion sometimes made, that a reduction of rates will take a specified sum out of the pockets of the railroad making such reduction, seems as fallacious as figuring our ton-mileage at what Mullhall said was the English rate, 2.8 cents per ton-mile, and claiming the $4 000 000 000 difference between rates as a loss to American railroads.

Mr. Whinery.

S. WHINERY, M. Am. Soc. C. E.—There are one or two points to which the speaker wishes to call attention. In all these projects for improving waterways for navigation, the question of the quantity of business to be accommodated must be carefully considered. It is not sufficient to assert that the territory penetrated is capable of affording a large business by the development of its natural resources; there must be a demand for these products along the route or at its terminals. The great deposits of coal that are tapped by the headwaters of the Warrior and Tombigbee Rivers will undoubtedly all be mined in the future and will find a market. It is not at all clear to the speaker that this market will be found at the City of Mobile, or at any other points that can be served by river transportation better than by rail transportation.

Mr. Whinery. According to the census of 1900, Mobile had a population of a little less than 38 500. In 1890 the population was slightly greater than 31 000. There is no reason to believe that, in the future, it will become a very large city, and still less reason to expect that it will become a great manufacturing center. The local consumption of coal, therefore, is quite certain to be comparatively small.

To what extent coal may be exported from this country is yet problematic, and even if the export business should become very large it is not at all certain that Mobile would secure a very large share of that business. The city is at the head of Mobile Bay, some thirty miles from the open Gulf, and it is reached through a long stretch of artificial channel which will, doubtless, require the expenditure of large sums of money for maintenance, and which, at best, is somewhat difficult of navigation.

The construction and maintenance at Mobile of a harbor of sufficient capacity to accommodate a very large export business will involve a further very large expense.

The distance to European ports is notably greater than from Norfolk and other points on the Atlantic seaboard where coal is available for export. On the other hand, Mobile is much nearer to Mexican, West Indian and South American ports depending for their coal supply largely upon importation.

There are no large cities in the region that would probably be supplied with coal through Mobile, as New Orleans will probably continue to get the bulk of its supply by the Ohio and the Mississippi Rivers, and Galveston could probably be supplied more economically by rail. Therefore, there is no assurance of a market at Mobile that would justify the very large expenditures of money required to make a satisfactory water route between the Warrior coal field and that city. Nor is it likely that any great points of coal consumption will be developed in the intermediate territory along the river. It is tacitly admitted by the author that the commerce of the region, other than relates to coal, could probably be taken care of at least as cheaply by rail as by river. In any event, it seems safe to assert that, whatever may develop in the future, there exists no commercial justification for these expensive improvements at this time. Even if it were certain that Mobile would supply an adequate market for the products along the route, it may be questioned whether, when all things are considered, the commercial business of the region served could be more economically transported to that market by water than by rail. Excluding the one item of coal, experience seems to indicate conclusively that in the great region of the Mississippi Valley river transportation cannot compete successfully with rail transportation. The history of the rise, the splendid achievement, and the decadence, in the face of rail competition, of water transportation on the Mississippi River and its tributaries has

never been adequately written. Such a history would be as interesting as a fairy tale, and it would teach lessons that have an important bearing on present transportation problems. There are plenty of men yet living who saw these rivers literally alive with commerce. They can recall the time when the Ohio and the Mississippi Rivers carried great fleets of vessels of all kinds, from the rude flatboat to the gorgeous floating palace, all loaded down with the commerce of the productive and prosperous region through which they flow. The ship-yards along their banks were busy with the construction of new vessels. But this magnificent river commerce has declined until it may be said to have practically disappeared, although the actual commerce of the region has grown to many times its volume in the days when river transportation was in its prime. The railroad has taken the place of the steamboat. There must be sufficient reason, or reasons, for this great change. Commerce, in attaining its end, seeks the lines of least resistance. The decadence of this river transportation must be accepted as proof that, all things considered, the steamboat could not compete successfully with the railroad. Mr. Whinery.

Analogies drawn from the wonderful expansion and success of water transportation on the Great Lakes, are, in the opinion of the writer, totally inapplicable to ordinary river transportation. The conditions are entirely different. The Great Lakes lie mostly between parallels of latitude which also embrace the most wonderful development of human activity and commercial enterprise that the world has ever witnessed. Between the parallels of 40° and 45° north lie a chain of great cities the like of which, in their number, in their rapid growth, in their present population, and in their commercial importance, can be found nowhere else in the world. The commerce of all this region is more or less tributary to transportation on the Great Lakes. Around their western end lies the great grain-producing region of the United States and Canada, and the course of this grain to its market is parallel with their length. Along their course and toward their westerly end are situated the most wonderful iron and copper mines yet developed on the Continent. At their eastern end is found the most extensive and valuable coal region developed in the Western Hemisphere. Within the zone and in the prolongation eastwardly of the general axis of the Lakes is the commercial metropolis of North America. The region tributary to them abounds in every element necessary to stimulate agriculture, manufactures and commerce. The minerals from the the West and the coal from the East must be brought together. These lakes, with their connecting rivers, aided by comparatively inexpensive improvements, barring the ice of winter, present almost ideal conditions for inland water transportation.

For these reasons, lessons drawn from the results of channel improvement on the Great Lakes must be applied with the greatest cau-

Mr. Whinery. tion to the problems of improving our river systems. Does any one believe that if the Mississippi and the Ohio Rivers, between Pittsburg, St. Louis and New Orleans, had navigable channels that would accommodate the present vessels on the Lakes, their commerce could ever approach, much less equal, that of the Great Lakes?

It is not to be overlooked that these rivers possess now, and always have possessed, during as many months in the year as the Lakes are open for navigation, a capacity for navigation sufficient to accommodate a much greater commerce than they ever carried even in the palmiest days of river transportation. The decadence of their commerce, therefore, must be sought in causes other than their lack of navigable capacity, and he would be a bold prophet who would predict that their former supremacy could be restored by any amount of channel improvement.

If Congress could be brought to consider the question of river and harbor improvements from the cool and deliberate point of view of the practical business man, there would be a revolution in the character of our River and Harbor bills. How many members of that body, who urge and vote appropriations for many government improvement works, could be induced, were they as rich as Crœsus, to invest capital in the same projects, as private commercial enterprises, even if they could control and reap all the profits both actual and contingent? What sane business corporation, for instance, if it owned all the territory in Kentucky and Tennessee tributary to the Cumberland River, would think it wise business policy to enter upon a project to improve that river at a cost of many millions of dollars? The Government is now engaged upon such a project, involving, if the speaker's memory is correct, no less than twenty-two locks and dams between the head of navigation and Nashville. It is safe to assert that a fair interest on the cost of this project, when completed, would be more than sufficient to pay the whole of the transportation charges by rail on all the business that the improved river would ever attract.

Applying the same line of thought to the improvements in progress and contemplated on the Mobile River and its tributaries, it may well be questioned whether they will ever yield returns sufficient to justify their construction. Considering all the conditions, it is an open question whether, if the coal deposits penetrated were all owned by a giant corporation and Mobile was the chief market for the coal, it would be found more economical to make use of the improved water route, rather than of the railroads, for supplying that market. Time does not permit the discussion of this question in detail, though some of the facts have been referred to by others in the discussion of this paper.

Mr. Rafter. GEORGE W. RAFTER, M. Am. Soc. C. E. (by letter).—To a student of hydrology nothing can be more interesting in Mr. McCalla's paper

than his reference to the floods in the Black Warrior River. The writer remembers, when living at Tuscaloosa, fifteen years ago, viewing with amazement the high-water mark on the piers of the bridge crossing the Warrior River at that place. It indicated that when in flood flow the stream spread over the valley, as Mr. McCalla states, for miles in width, and, for the time being, the Warrior River was, in effect, another Mississippi. **Mr. Rafter.**

The flood flows of this stream are undoubtedly very large, and their possible effect upon the river improvements is interesting matter for discussion.

The catchment area of the river at Tuscaloosa is given at 4 900 sq. miles, and the maximum discharge at 38.8 cu. ft. per square mile per second, thus indicating a total flood flow of about 190 000 cu. ft. per second. The minimum flow, on the contrary, of 150 cu. ft. per second, shows only about 0.03 cu. ft. per square mile per second, or the minimum flow may be taken at about $\frac{1}{1266}$ of the maximum.

The annual rainfall producing these flows is, as an average for ten years, from 1891–1900, inclusive, 48.59 ins. In Table No. 14 the writer has compiled the rainfall at Tuscaloosa for the storage period —December to May, inclusive— for the ten years, 1891–1900.

Table No. 14.—Rainfall at Tuscaloosa, Alabama, for the Storage Period, 1891–1900, Inclusive.

Year.	Annual.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Total of Period.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1891............	58.58	5.09*	8.43	10.28	9.38	1.70	1.72	36.60
1892............	52.95	4.88	6.88	2.50	5.40	3.16	2.92	25.74
1893............	50.00	4.42	3.08	8.27	4.41	2.61	7.10	29.89
1894............	48.51	4.29	8.57	4.73	5.18	4.46	0.69	27.92
1895............	51.94	5.97	7.42	2.24	7.30	2.77	4.81	30.51
1896............	40.09	5.74	4.11	4.11	5.19	4.74	3.52	27.41
1897............	41.46	1.11	4.43	4.83	5.63	4.07	2.71	22.78
1898............	43.65	8.08	6.65	1.46	4.91	3.73	0.19	25.02
1899............	50.15	3.43	8.14	3.96	7.63	2.60	2.22	27.98
1900............	.....	7.88	3.58	5.54	6.08	15.67	1.43	40.18
Mean.........	48.59	5.09	6.18	4.79	6.11	4.55	2.78	.....

* Mean of nine years.

The figures in Table No. 14 show that the total of the storage period varied during these years from 22.78 ins., in 1897, to 40.18 ins., in 1900. Although the total in 1900 was the largest of any during the period, it does not follow that the heaviest floods would necessarily take place in that year. Flood flows are dependent on other conditions than depth of rainfall, that is to say, their intensity will very largely depend upon whether or not the ground-water is high or low at the time of the occurrence of a heavy rainfall. If the ground is full of water at

Mr. Rafter. such a time, a given rainfall will produce a much heavier flood than if the ground-water is low.

Moreover, with other conditions the same, a given rainfall will produce a larger flood during the storage period than during either the growing or replenishing period. Taking the average of the United States, during the storage period, from 60 to 80% of the rainfall runs off; during the growing period, ordinarily only 10 to 15% runs off; while during the replenishing period, 20 to 40% runs off. These figures are very general, and may be departed from somewhat in special cases, but they serve to illustrate why extreme floods are more common in the storage period than at any other time.

The writer has defined the storage, growing and replenishing periods so frequently in his writings on hydrology that he assumes that they are understood by everybody, and hence does not repeat the matter here.

The specific application to be made of these flood data is that, with a sand and clay bottom, a very slight change in the regimen of the stream is likely to lead to extensive erosion, thus endangering the foundations of structures. Undoubtedly, this point has been attended to, and the writer merely mentions it as interesting in connection with the work on the Warrior system.

Mr. McCalla's paper is an exceedingly valuable one, and states in a forcible manner many of the important questions to be considered in the canalization of a river. One of the sections of dam proposed to be used, shown by Fig. 7, is a very satisfactory type, where an engineer builds timber dams. Other types of dams are shown by Figs. 17 and 18, but whether these will not at some time yield during an extreme flood flow can only be determined by experience. The writer cannot but think that Portland cement concrete would give more satisfactory results and prove quite as economical when the total cost for a term of years is considered; but as this phase of the question has been ably discussed by others, the writer merely refers to it at this time.

By way of showing how important it is that work be of the very best description, the following experience on the Erie Canal is pertinent: A few weeks ago, a break, involving two weeks' cessation of navigation, occurred at a culvert built in 1840. For sixty-two years this culvert has gone on doing its work, without, if the writer has been correctly informed, any repairs during the period, but suddenly, without warning, it gave way, and the masonry work of sixty-two years ago was laid bare. It appears that a bench-wall was built without any pretense of backing, with merely a veneering of thin face-stones, and how the culvert stood at all—why, in short, it did not go out when water was first let into the canal—is a mystery.

Mr. Belzner. THEODORE BELZNER, Jun. Am. Soc. C. E. (by letter).—*Notes on Sheet-Piling.*—Regarding the sheet-piles that were used at Lock and

Dam No. 4, Warrior River, which formed the inner and outer wall, Mr. Belzner. the writer believes that if a 3 x 12-in. pile had been used, made up of three pieces the full length of the pile, instead of being spliced, that the results would have been better.

The sheet-piles as first ordered at Lock and Dam No. 4 were made up as follows: One piece dressed, 2 x 12 ins. and 24 ft. long, and two pieces undressed, 2 x 12 ins. and 24 ft. long. The undressed pieces were spliced, the length of the pieces being about 18 ft. and 6 ft.; one piece being spliced at one end of the pile and the other piece at the other end.

The material for the pile was any variety of pine. Wire nails (6½-in.) were driven through from 1 in. to 18 ins. apart, staggered, and clinched. Three nails in a row were driven at the top and bottom of the pile and also at the splice joints.

The piles were driven with a 2 500-lb. drop-hammer in combination with a water-jet, the jet being kept at the point of the pile all the way down. The fall of the hammer was usually 5 ft., but at times it was necessary to increase the fall on account of obstructions and hard driving.

The pile drove easily through soft material, such as soil and fine sand, and the method seems to have been efficient where the pile was to be driven through a uniform stratum, free from logs and other obstructions, but under the conditions at Lock and Dam No. 4 these piles are not efficient.

They have not sufficient thickness to prevent a tendency to buckle when driven hard. The splice, also, lessens the resistance to buckling; therefore piles made up of three pieces, 3 x 12 ins., the full length of the pile, would give more satisfactory results, and also reduce the percolation considerably.

Driving.—The writer believes that it was not the purpose of the designer to drive the pile, but to jet it into place, short blows being used to make the pile sink over the jet, but the jet would often strike a log or some other obstruction and the pile could not be made to go down by this method. In such cases the pile was driven through, or often past, the obstruction. A deflection of the point was the result, accompanied by a bending of the pile in the leads above ground. Here was shown the disadvantage of the splice, and also of the pile being of small section. The pile often had to be bent in the leads, in order that driving might continue, without breaking the pile. A stiffer pile might have forced the obstruction from its way or might have been driven through it.

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PAPERS AND DISCUSSIONS.

THE MAINTENANCE OF ASPHALT STREETS.

Discussion.*

By Messrs. S. Whinery, Nelson P. Lewis, S. C. Thompson and J. M. Evans.

Mr. Whinery. S. Whinery, M. Am. Soc. C. E.—The question of the wisdom of requiring a long-time guaranty on public work, and particularly on street pavements, has not received the attention its importance warrants. Whether such guaranties, on the whole, are beneficial to the interests of a city, or otherwise, certainly admits of arguments on both sides. The arguments on the negative side, apparently, have not been worked out carefully or pursued to ultimate consequences or conclusions.

The speaker does not include in this discussion those short-period guaranties to the effect that any defective materials or workmanship appearing within a period of six months or one year shall be made good by the contractor, nor to those which require that machinery or plant shall accomplish certain stipulated results. There can be no question about the propriety and the advantage of such guaranties. Nor is it intended to discuss that class of guaranties which require that work constructed with comparatively unknown materials or performed by unusual methods shall fulfill the requirements stipulated. Without attempting at this time to enter upon a full discussion of the wisdom of requiring long-period guaranties upon street pavements, reference may be made to some of the more important arguments against the practice.

* This discussion (of the paper by James N. Hazlehurst, M. Am. Soc. C. E., printed in *Proceedings* for May, 1902), is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.
Communications on this subject received prior to November 21st, 1902, will be published subsequently.

Mr. Whinery.

The general theory upon which such guaranties are based is that the responsibility for the good and sufficient quality of the materials used, and of the workmanship and skill, is thrown upon the contractor under conditions which he cannot afford to disregard. In short, the object is to shift responsibility for the character of the work from the city authorities to the contractor. No one can object to this as a principle. The city is undoubtedly justified in taking any reasonable measures that will compel the contractor to comply fairly and fully with the requirements of his contract. The only question, therefore, that may be raised, is, whether, on the whole, such guaranties, in their practical workings, result, or can be made to result, to the advantage of the city. This embraces the question whether such guaranties, as they are usually framed, can be legally enforced, under the conditions that usually prevail in street-paving contracts.

In the first place, assuming that such guaranties are entirely legal, their value must depend upon the ability of the city to enforce them. Sufficient surety must be required from the contractor, and the question at once arises: What amount of surety is sufficient? It is a well-known fact, well-known, at least, to contractors, that the cost of maintaining a pavement under conditions to which it may be subjected for ten or even for five years may vary from 5 to 100% of its original cost. The cases are quite frequent where the cost of maintenance will equal 50% of the original cost, even where the work has been faithfully and skilfully done. In those cases where the work has been done by an unskilful or dishonest contractor it is not safe to figure that less than one-half of the original cost may have to be expended to make good the guaranty for a period of even five years, particularly if the streets paved are subjected to heavy travel. Consequently, it may be stated as a general proposition that the surety required from contractors, in the case of asphalt pavements, will not insure the city against loss unless it is equal in amount to one-half the cost of construction. It will at once be replied to this statement that enormous areas of asphalt pavement have been constructed in American cities under guaranties running from five to thirty years, where the amount of surety required has varied from only 10 to 30% of the contract price, and that defaults by the contractor have been rare and unimportant. But it must be remembered that the asphalt pavements of this country have been constructed under a peculiar set of conditions. The work has been done largely by a few large companies whose business interest in the promotion and extension of asphalt pavements was such that they could not afford to default on these guaranties, even if their business responsibility and honor had not impelled them to comply with obligations incurred.

There have been a great many cases in every large city having a considerable area of asphalt pavements where the surety in possession

Mr. Whinery. of the city has been less than one-third of the amount expended by the contractor to maintain the guaranty. There are many contracts involving a fifteen-year guaranty in existence in the City of New York, where the tangible surety in possession of the city does not equal one-half the amount it will cost the contractor to comply with the guaranty. It will depend entirely upon the honor and integrity of the original contractors or their successors, whether or not these contracts are lived up to until the end of the guaranty period. Sufficient examples have occurred to show what may be expected in cases where an irresponsible or dishonest contractor has been awarded work. The history of the asphalt pavement on Eighth Avenue, New York City, is a good illustration. How long the conditions prevailing in the past will continue, no one can say, but it may be safely predicted that, if the time ever comes when competition is as open in the asphalt-paving business as in other work, and when cities shall award contracts to the lowest bidder regardless of other considerations, it will be found necessary to require an amount of surety equal to at least half the original contract price.

There are two usual methods of providing surety for the integrity of such guaranties. In the one, a part of the money that would otherwise be due the contractor upon the completion of his work, is withheld from him until the expiration of the guaranty period. Now, if it be true that surety to the amount of one-half the contract price must be provided in order to make the city safe, the contractor would receive, under this plan, only 50% of the value of the work at his contract price. Knowing this, he must do one of two things. He may bid prices that will be sufficient, when 50% is retained, to pay the actual outlay for the work, or he may, if he possesses the capital or can command it, bid prices that will enable him to carry the retained balance during the period of the guaranty, as well as to pay the expenses of sustaining the guaranty. In the first case the work will be open to contractors of moderate or large means, alike, but the city must pay double the actual cost of the work. In the second case the contractor of moderate means will be shut out entirely, and a very few, of the wealthiest only, will be able to compete, and even then these wealthy contractors must bid prices that will compensate them for carrying the unpaid balance over a long period. In either case the city must pay the cost of the surety it requires. And, since contractors will usually bid prices that they think are on the safe side, particularly where conditions are such that exact cost cannot be determined, the city must usually pay a very high price for its security.

In lieu of retaining a part of the contract price, many cities require the contractor to give a bond with sureties deemed sufficient to make the bond good. These sureties may be either private persons or

surety companies. Personal surety is notoriously unreliable. Even if the persons signing a bond are perfectly responsible at the time, they may be paupers before the end of five years. Whatever may be the cause or causes, it is a notorious fact that not in one case out of twenty, in our American cities, where the bond is forfeited is recovery actually made from personal sureties. It results that most cities now require contractor's bonds to be under-written by surety companies in good standing. But these surety companies are naturally averse to signing the bonds, of even the most responsible contractors, where they extend over a considerable period of years, and if they consent to do so they charge high rates for the service, and usually require collateral security from the contractor. The contractor must meet the expenses thus incurred, and must bid prices that will cover them, and the city must in the end pay liberally for the surety it exacts. Mr. Whinery.

Without any intention of impugning the honor or the integrity of surety companies, it must be remembered that, corporations being without souls, they may possibly avail themselves of legal technicalities to escape the payment of large sums of money for which they are bound. Therefore, it is exceedingly important that no possible grounds of invalidity exist in contracts thus secured. In very few instances, the speaker believes, have surety companies been called upon to make good for defaulting paving contractors; but it is not impossible that, if called upon to pay large sums on account of such default, it would be discovered that even this class of surety is not always to be relied upon implicitly.

It has been claimed that contractors, in framing their bids, do not add much, if anything, to their prices to cover the expenses of a guaranty, but such a claim is too absurd to be considered seriously. The contractor, usually, is not a blockhead, and he is not in the business simply for benevolence or amusement. It is true, he cannot estimate exactly what it will cost him to maintain the guaranty, and if he is new to the business he may very greatly under-estimate that cost, but, whatever he thinks it may be, he adds it to the price he would otherwise bid, unless, indeed, he counts upon repudiating or escaping the guaranty entirely.

It may be that sharp competition, and a desire to control the business, will cause him to bid prices which he knows will not cover the cost of the work, but, if he has had any experience in the business, he knows that the cost of the guaranty is as palpable a quantity as is that of the pavement itself.

It must be evident, therefore, that the city must pay very liberally for the benefit the guaranty is supposed to confer.

In the second place, the question of the legality of long-time guaranties demands more consideration than it has received. Where pavements are paid for by special assessments upon the property

Mr. Whinery. benefited by the improvement, the courts have held, almost universally, that while the original cost of the improvement may be assessed against benefited property, the subsequent cost of maintaining the work cannot be thus assessed. In those decisions which uphold the validity of time guaranties, this principle is not denied, but an attempt is made to evade it. They set up the plea that the terms of the guaranty do not necessarily require the maintenance, in the proper sense of the word, of the pavement, but only that the contractors shall do the work with such materials and such skill that maintenance will not be necessary during the guaranty period; and if it shall become necessary to repair the pavement within that period, the fact is simply evidence that the contractor did not do the work in the manner required, and, therefore, must make good the consequences of his failure. This reasoning, in the speaker's opinion, is specious and erroneous. It may be sound, as an abstract legal theory, but, when confronted by the facts as they are known to every practical man, its sophistry cannot but be apparent. It may be safely asserted that no street pavement, subjected to even moderately heavy travel, will endure for five years, much less for a longer period, without the necessity for more or less repair, which no fair-minded person competent to judge can attribute to defective construction. The use of the familiar phrase, "ordinary wear and tear excepted," in very many guaranty clauses tacitly admits the fact. It is obvious that the repairs necessary to a pavement after it is two or three years old may be divided into two classes: First, those that may be due to the use of materials or labor not up to the requirements of the specifications; and, second, those made necessary by the wear and tear of use, whatever may have been the character of the original construction. Under the general principle of law referred to above, the contractor, in the first case, may be clearly held to his guaranty without danger of legal complications. Under the second, the property owner may justly object to being assessed specially for what is clearly maintenance of the work.

The decision of the Alabama Court, cited by the author, it seems to the speaker, is a striking example of fine-spun legal theory misapplied to practical facts and conditions. The learned judge concludes his decision with a fine-sounding dictum which was doubtless intended as a clinching argument in the legal knock-down of the whole fabric of the theory opposed to that held by the Court. Speaking of the requirements of the guaranty clauses in question, he says: "It is an incident of the contract, not an independent undertaking."

When, it may be asked by the practical man devoid of legal acumen, does such a guaranty clause cease to become an incident of the contract and not an independent undertaking? If it is an incident until the end of five years, why not until the end of ten years? And why may

it not continue to be an incident during the whole life of the pavement? Mr. Whinery.

If it is answered that it continues to be an incident only as long as may be necessary to establish the fact that the work was done with such material and skill as the contract called for, other questions arise. Just what length of time is required to disclose defective workmanship and materials? Is that period of time, assuming that it can be determined, a fixed and well differentiated period, or may it be affected by conditions which must vary with different streets, and even with different parts of the same street? Is the "incident" period the same on such a street as Broadway, New York City, and on the residence streets of the smaller cities, or even of those of New York City? Is it true that five years' use of a pavement on a heavily traveled street in any large city will develop nothing more than inherent defects in the original construction? And, that the effect of wear and tear of travel, which is not an incident of the contract, will begin the day after the expiration of the five years and not before? And, if it does not begin on the last day of the five years, when will it begin? If the guaranty of the pavement and the expense of maintenance it entails is merely an incident of the contract in the sense the Court seems to hold, would the contractor add anything to his price because of the incident? If it is found, as a matter of fact, that the expense of maintenance entailed by the guaranty is invariably added by the contractor to his estimate of first cost, or is always considered in fixing the price in his original bid, does the Court still hold that it is merely an incident of the contract?

Notwithstanding the great importance of the question of the validity of these long guaranties, decisions of the higher Courts covering it have been comparatively few, but a large majority of these have been to the effect that they are not legal when they relate to work paid for by special assessment. Cases involving the legality of these guaranties apparently have not been brought before the Courts in a large majority of the States, and in these it remains an open question. The far-reaching effects and the serious financial results which would attend adverse decisions in many of the older States, where hundreds of thousands of square yards of asphalt pavement are covered by such guaranties, make the question one of very serious importance.

The absence of litigation and resulting decisions in so many of the States may be largely due to the fact that the large companies by whom the greater part of the asphalt pavement in this country has been constructed have, for reasons of their own, consented to, if they have not actually encouraged the requirement of, long-time guaranties.

There is one important feature of these long-time guaranties that seems not to have been brought before, or considered by, the Courts

Mr. Whinery. at all; that is, that in nearly every city the terms of contracts for paving, including the guaranty requirements, are general, and are made to apply to all streets alike. No allowance is made with respect to different streets for different conditions of use. Thus *A* and *B*, two parallel and contiguous streets, are paved at the same time, under the same form of contract, and possibly by the same contractor. *A* is a main business street with very heavy travel, while *B* is a residential street, with very little travel. The work on both may be done with the same materials and with the same degree of care and skill, so that the pavements when completed are practically identical. The contractor, in framing his bids, having the facts in mind, would almost certainly bid a higher price per square yard on *A* than on *B*, because the maintenance of the pavement for the guaranty period will cost very much more on *A* than on *B*. Let it be assumed that the period of guaranty on *B* be such that its pavement would just endure to the end of the period without any repairs due to maintenance proper. During the same period, the pavement on *A*, subjected to very heavy travel, will have required a large expenditure for repairs due to the wear and tear of use. To pay for the pavements, the property owner on *A*, obviously, must be assessed for a much larger sum per unit than the property owner on *B*. If the property owner on *A* should resist the assessment on the ground that a part of his assessment was for maintaining the pavement and not for construction, and should appeal to the Courts, it is difficult to understand upon what ground his plea could be refused, or the validity of the guaranty sustained. This particular ground of invalidity could be avoided by such a change in the nature of the guaranty as would require that the pavement should endure a stipulated, definite quantity of use, without showing indications of failure, as, for instance, the passage over it of a certain number of tons of travel, the quantity to be ascertained by censuses of travel taken at intervals of time in accordance with specified rules and regulations. The speaker has long believed that this is quite practicable, and that it constitutes the only rational and just basis for guaranties that are intended to test the endurance of a pavement.

At this point may be considered some provisions of these guaranties which have their foundation in the attempt to keep their requirements within legal bounds.

If the contractor is required to maintain the integrity of a pavement for a period of years, care must be taken that nothing is done by the city, or by other persons with the permission of the city, that will release the contractor from his obligation. For instance, the city may not remove and then repair a part of the guaranteed pavement, nor may it authorize persons other than the contractor to do so, since not only may the contractor claim that the adjoining pavement was injured in the operation, but he may claim that defects appearing

Mr. Whinery.

later are within the area of the pavement disturbed and repaired by parties other than himself, and for which he cannot, therefore, be held responsible. It is generally difficult, if not impossible, even with the aid of carefully prepared diagrams, to locate accurately, after the lapse of a year or two, the exact boundaries of such repaired areas. Therefore, it has been found desirable, if not essential, to couple with the guaranty a provision that the guarantor shall make all necessary cuts into and replacements of the pavement, at a stipulated price. Usually, not much consideration has been given to the reasonableness of this price, as it has been assumed that it was an unimportant item. Very commonly, the price has been fixed at a certain percentum above the contract price for the construction of the pavement. If, therefore, the guaranty period was long and the contract price accordingly high, the price for such repairs was quite likely to be exorbitant. The result is illustrated nowhere better than in New York City, where, owing to extensive improvements in transportation systems and other underground structures, enormous areas of pavement have to be removed and replaced at prices so high as to make the cost of the work a very serious burden to those who must pay for it. It is probably true that this repair work is to-day, in New York City, the principal source of profit to the contractors who laid the pavement, or to their successors. Even if the price for repairs, thus stipulated, were reasonable at the time the contracts were made, the great decline in the cost of asphalt pavement since that date makes them now abnormally high, and suggests the conclusion that it is unwise to continue a practice which seems necessarily to involve the making of contracts extending over long periods of time for supplies or services, the market value of which is likely to be subject to great fluctuations.

Before dismissing this branch of the subject, it is worth noting that, where maintenance is embraced in contracts for construction, the cost of maintenance being embraced in the price bid, the contractor practically receives payment for the maintenance in advance, and, in the cases of long-period guaranties, so many years in advance that the resulting loss to the city is very great. In some of the contracts for the pavement of Broadway, New York City, it is very evident that the contractor, in fixing the price bid by him, regarded the maintenance as likely to cost nearly twice as much as the construction. Yet the city paid him the whole sum upon the completion of the work of construction. It is true that a large percentage of the sum was retained by the city, but this was held as surety, additional to the bond given, for the performance of his obligations (and it may be said, in passing, that as security it was very inadequate), and was not withheld with the view of paying for a part of the service when that service should be rendered. When it is considered that the largest part of the cost of maintenance will almost certainly be expended in the last half of the

Mr. Whinery. guaranty period, it will be appreciated that the advance payment must be a matter of large gain to the contractor and of large loss to the city.

There is another point which is of sufficient importance to merit consideration in this connection. If the city requires the contractor to guarantee certain results, he may justly claim that he must be left free as to the means by which these results are to be obtained. and that if the city assumes to dictate, as by prescribing definite specifications and the means to be used, he, the contractor, cannot be held responsible for results. It would seem, therefore, a very dangerous procedure, from a legal point of view, for a city to attempt to compel a contractor to guarantee work, constructed not in accordance with his judgment and experience, but in strict compliance with specifications formulated by the city's agents.

In the early history of asphalt pavement, when its merits were questioned and distrusted, when the properties of the material used were not well understood and the methods of constructing it were not familiar to engineers, it cannot be doubted that the requirement of some guaranty of results was not only justified, but was required by ordinary business prudence. But that time is now past. The essential quality of the material is known and can be determined in the laboratory or by experiment, and the principles of its construction are well understood. The fact that engineers do not now hesitate to prescribe how the work shall be done, down to its minutest details, is sufficient evidence that they feel competent to deal with the subject as freely as with any other engineering problem.

It is scarcely creditable to the profession that in the present state of the art and science of pavement construction we must depend upon contractors' guaranties to secure good work.

The necessity for a guaranty of endurance, therefore, seems no longer to exist. In view of these conditions, and others which time does not permit the speaker to detail now, he is, and has been for many years, of the opinion that it is both unnecessary and unwise to continue longer these long-time, or, as they may more properly be called, endurance, guaranties. He does not believe that, upon the whole, they result to the advantage of the cities, or are worth what they cost. There seems to him to be ample evidence that, whether judged from the economical or the legal standpoint, it is unwise as well as dangerous to complicate construction contracts with provisions for maintenance in such a way that they are not readily separable. A guaranty extending over a short period, sufficient to disclose defects of construction that might have been overlooked as the work progressed, would be entirely unobjectionable. It should not extend over two years. With such a guaranty our cities can safely rely upon their engineers to prepare adequate specifications, and to enforce them so as to secure work

of the highest standard of excellence. In cases where the local engineering talent may happen to be without the requisite knowledge and experience, there are not a few specialists whose services could be readily secured, in the capacity of consulting engineer, as is the practice in other branches of engineering work. Mr. Whinery.

If it is thought advisable, maintenance of the pavement, after the expiration of the short guaranty, can be made by contract either with the contractor who constructs the pavement or with others.

Some of the advantages claimed for the long-period guaranty could be secured by embracing in the original contract for construction provisions for the maintenance of the pavement, after the expiration of the short guaranty, at a stipulated price per square yard per year, payable yearly when the service shall have been rendered. In case the work is to be wholly or partly paid for by special assessments, only the cost of construction could then be assessed upon property owners, and the cost of maintenance could be paid from the general funds of the city.

The speaker agrees with Mr. Lewis that the plan adopted by the author is in the right direction, if long-period guaranties are to be continued, as it attempts to separate the guaranty from maintenance. But the plan adopted involves, to some extent, the common fallacy that the cost of guaranteeing the work on one street is practically the same as on any other street. Thus, the author bases his price for maintenance on the average cost of maintenance in Washington and other cities, ignoring the fact that the conditions in Mobile may be such as to make such average cost totally inapplicable to the streets of that city. If his plan were adopted in New York City under general specifications, used, as is customary, for the whole season's work, the absurdity of applying the Washington average, or of assuming that the specified maintenance price would apply alike to Broadway and to a short residential street in the Borough of the Bronx, would be palpable. If the author had carried his plan a little further and had asked bidders to name prices for maintenance during the second and third periods of five years, as well as a price for construction, he would then have approached a rational method; but even then he would have compelled the contractor to guess at the conditions that would probably prevail on a certain street fifteen years in the future. The speaker uses the word "guess" purposely, because, in our comparatively young and rapidly developing American cities, no one can foretell what changes in the growth and distribution of travel on any street may take place within a period of even ten years.

Mr. Lewis evidently has the impression, which is thought to be quite general, that the contractor, in making up his bid, adds little or nothing, to his price for construction, to cover the guaranty.

In making up hundreds of bids every year, the speaker, for himself

Mr. Whinery. and for the company with which he was for a long time connected, always added to the computed construction price on each street the estimated cost of maintaining the guaranty. The price thus arrived at, however, was not always the price his company bid, because various circumstances and the exigencies of competition often dictated the price, regardless, within certain limits, of the estimated cost.

Mr. Lewis. NELSON P. LEWIS, M. Am. Soc. C. E.—The author has the object of trying to eliminate the necessity of a contractor making a guess at the cost of maintaining a pavement which may be laid by him during the period for which such maintenance will be required. His object is certainly a commendable one, and the speaker believes he is moving in the right direction.

Let us see just how his specifications work out. They provide that all repairs which may be ordered during the period of the contractor's guaranty will be paid for, if the area is less than 20 sq. yds., at a price 20% greater than his original contract price, while for areas between 20 and 50 sq. yds. the advance will be 15%, and for areas over 50 sq. yds. 10% over the contract price. He refers to contracts let in Mobile for 17 000 yds. of pavement at $1.15 per square yard. The amount paid for repairs, therefore, will be $1.38 per square yard, if the area be less than 20 yds. If more than 20 yds. and less than 50 yds., $1.32¼; while for any repairs covering more than 50 yds., he will be paid $1.26½ per square yard.

Now, he assumes as a proper maintenance cost to the city for the first five-year period after the expiration of a five-year guaranty, or for the second five years of the life of the pavement, 3 cents per square yard per annum. Of the 17 000 sq. yds. laid in Mobile—assuming that practically all the repairs are in areas of less than 20 sq. yds., as will, in the speaker's opinion, be the case in a successful pavement—he would be expected to relay about 370 yds. annually during the first five years, or 2.2% of the total area each year. For the second five years, during which he is allowed 8 cents per square yard, he could relay just about 1 000 sq. yds., or 6% of the total area each year. Now, if he assumes that none of these repairs overlap each other, which is not probable, he would have renewed during those ten years, from the fifth to the fifteenth year, 41% of the original surface. Of course, there will be more or less overlapping; repairs will wear out and have to be renewed, and it is fair to assume that, say, one-fifth of the repairs made will have to be done a second time, so that the contractor will have replaced one-third of the total area of the pavement by the end of fifteen years.

Has the author adopted a fair standard when he refers to the cost in the City of Washington? The speaker does not believe he has. Washington is not a logical city, to which one may look for such a standard, especially if it is to be applied to a small city which is just beginning

to lay smooth pavements. The conditions in Washington are nearly ideal. The streets are extremely broad, the traffic of the city is comparatively light, and it is admirably distributed. In smaller cities, when smooth pavements are first laid, an abnormal amount of traffic is always attracted to them. This is invariably the case, and it is impossible to predict what will be the relative amount of traffic on new, smooth pavements. The character of a street will be radically changed within two or three years, possibly, after it is paved. Even in a city having comparatively a large amount of smooth pavements, a remarkable transformation will take place in the vehicular traffic as new routes are laid out and new connections are established. Mr. Lewis.

While the author may have given the contractor a good guessing basis, he is still going to make him guess. He is compelled to guess how much he will have to add to his construction price in addition to the 3 cents per square yard allowed for the second five-year period, and the 8 cents per square yard for the third five-year period, or, in other words, how much more than 40% of the original surface of the pavement will have to be renewed by the end of fifteen years, and he is going to guess liberally if he is a shrewd man. The contractor in Mobile evidently did not make a very liberal allowance, as his price was only $1.15 per square yard.

It is evident from the specifications which are quoted in the paper that if the contractor does not have to lay as much as was anticipated, that is, if he does not have to renew 2.2% annually for the first five years and 6% annually for the second five years, he is not to be paid for it.

Now, there has been a good deal of what the speaker will venture to call nonsense said and written about long-time guaranties and short-time guaranties, and the reasons for one or the other.

In a report made to the Mayor of New York City by his Commissioners of Accounts in 1899, there was a table tending to show what the insurance cost of pavements had been, that is, what premium the city was paying for long-time guaranties, and in estimating that cost they allowed 2 cents a square yard annually for the maintenance of New York pavements, amounting to 30 cents per square yard for the entire fifteen years, which was the guaranty period in the contracts under discussion. If this sum were all charged to the ten years from the fifth to the fifteenth, it would amount to only 3 cents per square yard per annum, and it cannot be claimed seriously that New York pavements can be maintained for 3 cents per square yard between the fifth and fifteenth years. The table also includes the cost of a plant for fifteen years at 5 cents per square yard annually, and the last and largest item is interest lost on money retained for fifteen years at 6%, amounting to 64½ cents, showing that the total cost to the city for insuring its pavements for fifteen years is 99½ cents per square yard.

Mr. Lewis. It is difficult to understand how it can be claimed seriously that the money retained under a paving contract, as it is in New York City, is wrongfully kept from the contractor, and that he should be allowed and will charge interest on it. It is not money which has been earned.

Mr. Whinery has referred to cases where 50% of the amount due the contractor has been held back that should have been paid to him on the completion of his work. It is probable that he did not refer to the New York City practice, but to cases where no bond is required.

The amount retained by the City of New York under the fifteen years' guaranty was 30% of the cost of the asphalt surface, of which 3% was paid each year, beginning at the end of the sixth year and up to the end of the fifteenth; that is, it was assumed that 3% of the cost of the pavement, which, at $2 a yard, would be 6 cents, or, at $3 a yard, 9 cents, was the amount which the contractor would probably earn in making those repairs, and this seems to the speaker a fair allowance. In the case of the ten-year guaranty, the amount retained was 20% of the cost of the wearing surface, of which 4% was paid at the end of each year from the sixth to the tenth. This allowance again would be, on the basis of $2 and $3 pavements, 8 or 12 cents per square yard. But that money was not earned; it was not due the contractor, and to charge it up as the price the city was paying for long-term guaranties was erroneous and misleading.

The speaker, however, agrees with the conclusions reached, and the contention that the long-term guaranty is unwise, but his reasons are entirely and radically different. It is probable that an asphalt-paving contractor, who is jealous of his reputation, will charge little, if any, less for a pavement without a guaranty than if he were guaranteeing it for five years, assuming that he would exercise the same care in laying the one as the other.

Streets differ so much in the traffic they sustain, and, as already stated, the future of a street is so uncertain, that when one deals in futures of more than five years he certainly has to estimate liberally, and the contractor is obliged to guess, and guess liberally, how much he will have to spend from the fifth to the fifteenth year.

But conditions are changing in a large city like New York, and they are changing for the better, and account should be taken of the changes. Steel tires are wider than they were, a large proportion of them has been replaced by those of rubber, horse-shoes are lighter, and one will not discount the future properly if he does not take into account the large percentage of horseless, smooth-wheeled vehicles which will be found on our streets before a ten or a fifteen-year contract made at the present time will have expired. All of these changes will tend to simplify the problem of maintaining our asphalt pavements. The elements most injurious to them are constantly being eliminated.

Now, is it not the plain duty of the municipality to take advantage

of these changed conditions instead of giving all that advantage to the contractor? It will be his if he is obliged to make a guess upon the cost of maintaining a pavement for fifteen years. He will base his guess upon his past experience with pavements now ten and fifteen years old, and it can scarcely be questioned that the conditions will be so different in another ten or fifteen years that the advantage will all be his. Mr. Lewis.

The speaker would like to suggest what seems to him a logical method of dealing with this problem, and one which will eliminate it almost entirely. It is that, after the expiration of the original contract covering not more than five years, subsequent contracts for from one to five years be made for maintaining the pavements, which contracts should provide that the contractor be paid for the material actually used, and which would be placed where directed.

This system has been in vogue in the District of Columbia for some years, and with admirable results. It is doubtless true that the figures which the author uses, viz., 3 cents per square yard as the cost of maintenance for the second five-year period and 8 cents per square yard for the third five-year period, are due largely to the use of this method, although, if the speaker correctly reads the recent reports of the District of Columbia, the average cost from the fifth to the tenth year is below 3 cents, and from the tenth to the fifteenth year below 8 cents. It is probable that the 8-cent average is obtained by including, as the reports do, a number of streets which are entirely re-surfaced and which increase the apparent cost very materially.

This same method is now in use in the Borough of Brooklyn, the second contract made on this basis being now in force. Under these contracts the wearing surface is paid for by the cubic foot, measured in carts on the street. The first contract provided for a payment of 97 cents per cubic foot for the wearing surface; the present price is 90 cents a cubic foot, while, with the burner method, or the skimming process, the price under the old contract was $1.15 per cubic foot; under the present one this method of repair is not provided for at all, it being considered unsatisfactory and to be discouraged, while the price for binder was, under the first contract, 35 cents a cubic foot, and under the present one 50 cents.

A great element of saving under such a contract is in repairs to streets, which, from their age or traffic, have been reduced in thickness. Many streets, doubtless, will be found in which the wearing surface, instead of being 2 ins., is 1½ ins., and in some instances less. Formerly, when repairs were paid for by the square yard, as is provided for under the plan proposed by the author, the city would pay for a standard pavement 2 ins. in thickness, and with 1 in. of binder, when it gets considerably less But, by the cubic-foot method, the same amount will lay a proportionately greater area, and while the amount

Mr. Lewis. expended under the Brooklyn contract was perhaps as much as under the old method, still the repairs were put where they did the most good. It enables one also, in the case of extremely bad pavements which need re-surfacing, to repair only the dangerous places and keep them in safe condition for a year or so, until they can be re-surfaced, without spending a large sum.

As already stated, the conditions in Washington are exceptionally favorable, but recent reports from Rochester would indicate that the repairs to its asphalt pavements cost even less than in Washington. The record, as given in the report of the City Engineer for 1900, is quite remarkable. The average cost for all streets is not given, but taking a pavement which was laid in 1886: From 1896 to 1900 the cost of maintenance per square yard per annum was 1.2 cents; another one cost 6.6 cents, and the next one 4 cents. These are the averages from the tenth to the fourteenth year. The next one is 2.8 cents, and one, on which the guaranty expired in 1892, appears to have been maintained since that date at an average cost of less than 1 cent per square yard. This is an admirable showing, and, judging from the limited opportunities the speaker has had to observe the Rochester streets, it is not because the repairs have been made spasmodically and only when necessary, because the streets have been kept in excellent condition. The City Engineer also states that in making the figures the area between railroad tracks and 2 ft. outside was excluded from the area of pavements maintained and in the cost, as these spaces are cared for by the surface railroad companies.

In reply to the question as to the reason for the cracking of asphalt pavements subjected to little or no traffic, the speaker believes that such pavements do have a tendency to crack more than those which are subjected to moderately heavy traffic; the reason, undoubtedly, is that in unused or little used pavements the wearing surface is not kept thoroughly compressed, and is therefore much less dense, and the action of the elements on the bitumen, the function of which is to hold the mineral matter together, is quite marked. Traffic does keep the surface more dense, and therefore more impervious to water, and better protected against the action of frosts.

Mr. Thompson. S. C. Thompson, M. Am. Soc. C. E.—In considering the question of maintenance of asphalt, the speaker desires to call attention to some conditions which obtain in the Borough of the Bronx. Quite a number of strips for the use of bicyclists have been constructed in the roadways of the different streets and avenues. They are usually from 3 to 5 ft. wide, or of such a width as to prevent both wheels of a vehicle getting on them.

In most cases these strips have been laid on the old block pavement as a foundation. The blocks have been lowered and the asphalt wearing surface placed on the top, and brought up to the same cross-

section as the remainder of the roadway. Most of these strips have been placed next to the curb. The result, in one street in particular, has been that the maintenance has been very expensive for the contractor, as the block pavement in the gutters, under the asphalt, allowed the water from the crown of the street to get under the strips, and, by its disintegrating influence and through the effects of frost, quite a large portion of the strip has been destroyed. This has made its renewal necessary at least twice during the past five years, and the speaker's belief is that it was due almost entirely to the fact that the foundation was unsuitable. The water draining from the crown of the street and getting under the asphalt caused it to crumble, so that it would not hold together, and the rolling received from the traffic was not sufficient to keep it in proper condition. Mr. Thompson.

This calls attention to another matter, in the same line, viz., paving with asphalt upon old blocks in general. The speaker desires to go on record as being opposed to the laying of asphalt on old block pavement, as done at the present time in New York City. The condition that exists is as follows: A street on which traffic has pounded the blocks down securely and solidly to a firm and unyielding foundation is to be repaved. The first thing that is done is to remove the blocks, excavate some of the earth, replace it with a sand bed, and relay the block pavement on the lower grade, thus getting the foundation into the very condition that is not wanted, viz., it is not thoroughly compacted and is easily moved. After leaving the street open to traffic for longer or shorter periods, varying according to the conditions that exist and the demands of traffic, the asphalt is laid upon these blocks.

Having had a good opportunity to observe work done in this manner, it is the speaker's opinion that satisfactory results cannot be obtained thereby. If the asphalt could be laid directly upon the old blocks, which have been pounded down thoroughly by the traffic, good results would be obtained, but, if openings are to be made in the roadway after laying, these results will not be as satisfactory as when a uniform foundation, like concrete, is laid.

J. M. Evans, Assoc. M. Am. Soc. C. E.—The criticism has been made that an asphalt pavement must be subjected to a rolling process, similar to vehicular traffic, in order to insure it remaining in place; and, to substantiate this claim, certain people point, with more or less justification, to the walks in our parks and other places, such as plazas, footbridge floors, etc., where the asphalt is badly cracked, or has been displaced by frost. Mr. Evans.

The speaker would like to enquire whether this is a fact, or whether it is the fault of the foundation or the quality of the material used in the surface; also, if asphalt walks, as laid at the present time, are as durable as the concrete walks of the so-called granolithic and kindred variety?

Mr. Evans. As granolithic pavement is now put down, with joints to allow expansion, it has proved very efficient in New York and other cities. The claim is made for it that, under light showers, it does not present as greasy and slippery a surface as asphalt, and that it can be laid without an expensive plant. Is it practicable to lay asphalt with joints to allow contraction, and thus prevent cracking; and, if so, will the rolling traffic still be necessary to preserve the surface intact?

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PAPERS AND DISCUSSIONS.

THE FLOW OF WATER IN WOOD PIPES.

Discussion.*

By Messrs. E. W. Schoder, A. V. Saph and Mansfield Merriman.

E. W. Schoder, Jun. Am. Soc. C. E. (by letter).—So much has appeared in recent hydraulic literature† about the use of logarithms and logarithmic cross-section paper in plotting the results of experiments on loss of head in pipes that it seems remarkable that the author apparently did not avail himself of this most efficient means of examining his results. If the loss of head varies as any power of the velocity, then a logarithmic plotting will yield a straight line, and if the "friction head" varies approximately as the velocity head, then the slope of this line will be approximately 2. Had the author plotted his results in this manner it seems extremely doubtful if he would have proposed the formulas which he did. Mr. Schoder.

The writer presents in Fig. 12 a logarithmic plotting of the data by

* This discussion (of the paper by Theron A. Noble, M. Am. Soc. C. E., printed in *Proceedings* for August, 1902), is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.
Communications on this subject received prior to November 21st, 1902, will be published subsequently.

† Osborne Reynolds, F. R. S., in *Transactions*, Royal Society, Vol. 35.
W. E. Foss, Member, Boston Soc. C. E., in *Journal*, Association of Engineering Societies, June, 1894.
Desmond FitzGerald, Past-President, Am. Soc. C. E., in *Transactions*, Am. Soc. C. E., Vol. xxxv, p. 241;
Gardner S. Williams, M. Am. Soc. C. E., in *Journal*, Association of Engineering Societies, Mar., 1901, pp. 170-174;
C. W. Sherman, Assoc. M. Am. Soc. C. E., in *Transactions*, Am. Soc. C. E., Vol. xliv, p. 84;
Messrs. Williams, Hubbell and Fenkell, in *Transactions*, Am. Soc. C. E., Vol. xlvii, p. 180;
Messrs. Saph and Schoder, in *Transactions*, Am. Soc. C. E., Vol. xlvii, p. 814.
Undoubtedly there are many others which have not come to the writer's attention.

Mr. Schoder. the author, by Messrs. Marx, Wing and Hoskins, and by Arthur L. Adams, M. Am. Soc. C. E., all referred to in the paper.

It is evident at a glance that the slope of the lines for the 44-in. and the 54-in. pipes is less than 2. As nearly as it can be scaled the slope for both these lines has the same value, 1.73. In other words, the loss of head in the author's experiments varies, not as the square, but as the 1.73ths power of the velocity.

An examination of Fig. 12 will show that the points fit the lines much better than in the author's plotting in Fig. 10. This is to be expected, in view of the fact just stated concerning the actual law of variation. The author has carried on a more consistent set of experiments than he himself was led to believe—a most unusual occurrence.

The data for the 14-in. pipe give the same slope, 1.73, as nearly as can be judged, the number of observations being too few to render an accurate determination possible.

Upon plotting the data of Messrs. Marx, Wing and Hoskins' experiments on the Ogden 72-in. pipe the writer was puzzled by the lack of harmony of the results. Considering first the 1897 experiments on a 2 710-ft. section, the slope of the line best representing the points is almost the same as for the 14-in., 44-in. and 54-in. pipes, but the centers of gravity of the five general groups of points do not even approximate to a straight-line effect. Exercising his best judgment, the writer has drawn the dashed line in Fig. 12. This line is parallel to the lines for the three smaller pipes. However, if equal weight be given to all the 1897 observations, the slope of the line would be appreciably less than 1.73.

The experiments of 1899 on the long section (22 710 ft.) give a much better line, the slope of which, however, is 1.94! The 1899 experiments on the short section do not give a straight line, but the points, in a general way, check roughly the evidence of the long section just mentioned.

How is this condition of affairs to be explained? The same experimenters on the same pipe line, in 1897, find that the loss of head varies about as the 1.73ths power of the velocity and in 1899 find that the variation is as the 1.94ths power of the velocity! In other words, for the designed capacity of the pipe line, or a velocity of 8¾ ft. per second, the 1899 experiments indicate a loss of head about 40% greater than the 1897 experiments!

Had the pipe deteriorated in the two years? The author states that there was considerable growth in the 54-in. pipe of the Seattle water-supply system as the result of one year's service. There was not enough, however, to make any appreciable difference apparent between the slopes of the lines for the 44-in. and the 54-in. lines. It is quite certain that any considerable increase of roughness of the in-

Mr. Schoder.

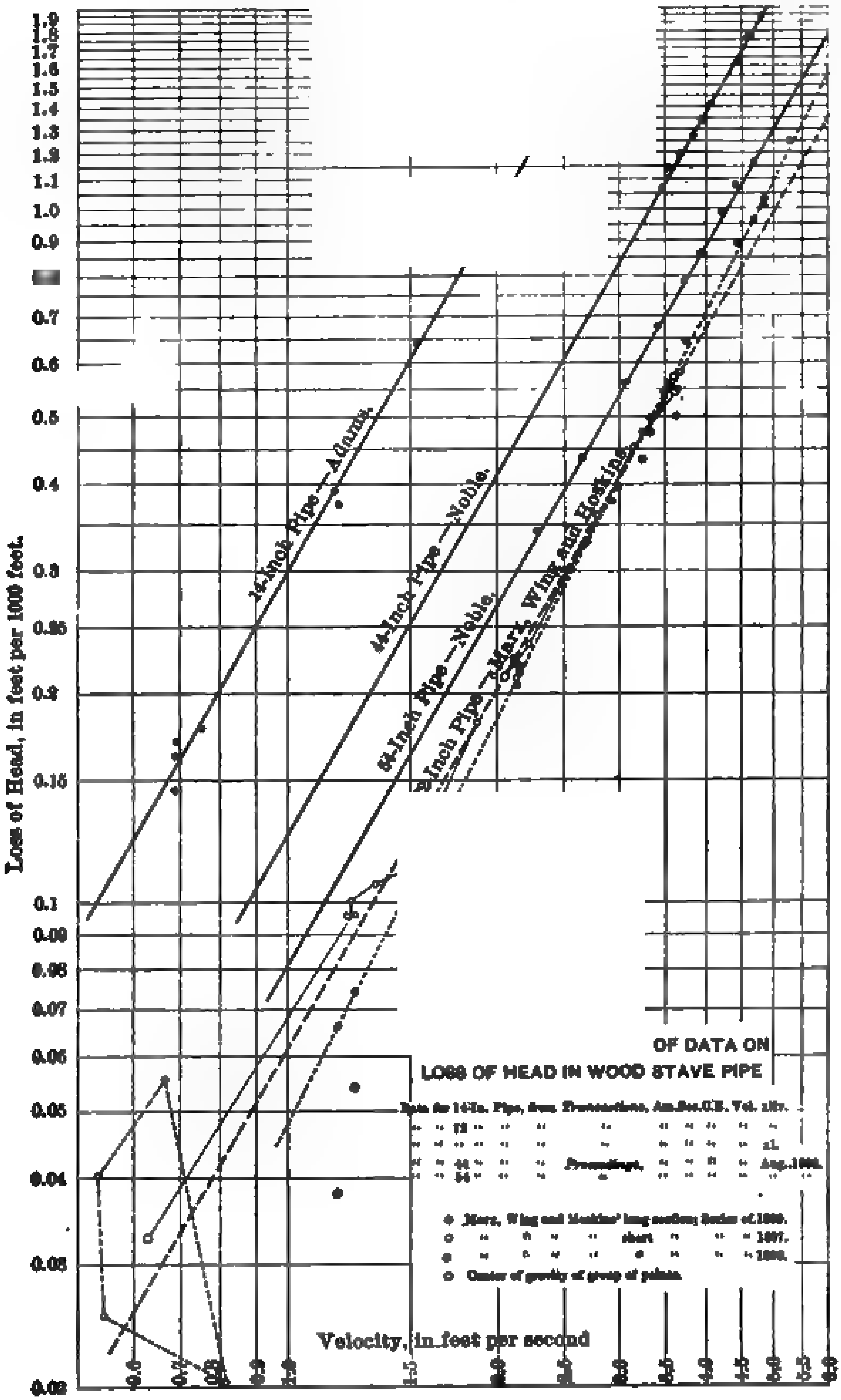

FIG. 12.

Mr. Schoder. terior wall of a pipe will cause the loss of head to vary with an increased power of the velocity.

The writer hopes that the question as to whether there was any difference in the interior of the Ogden line at the two times of experimentation, in 1897 and 1899, may be answered, either by careful examination in the future, or another set of experiments. If the latter should be undertaken it is hoped that some additional device for measuring velocity will be used as a check on the Venturi meters, which are placed just beyond curves which in turn follow a breeches pipe or Y.* The result is that the water reaches the meters in a very much disturbed condition, and, as a consequence, the readings of the up-stream piezometer of the meter are far more unreliable than if a long stretch of straight pipe led to it. The higher the velocity, the more unreliable do the indications become, so that at a high velocity, where measurements are generally considered most reliable, they are here most unreliable.

The assumption that the loss of head varies as the velocity head, or as the square of the velocity, is undoubtedly sufficiently accurate for most cases which occur in designing water-supply systems, especially when the range of velocity is within the range obtained in reliable experiments, and when, as is usually the case, the pipe line in question is of cast iron or of riveted steel, and, perhaps, in addition, is a feeder for numerous branch lines. In the case of long wood stave pipe lines, however, which are perfectly continuous, as in the case of the Ogden and Seattle lines, it would seem that such an approximation should be replaced by a formula which more nearly expresses the conditions. The only question, as already hinted, is as to the deterioration of the pipe owing to spongy or slimy growths, but, certainly, if it be found that these occur, the engineer will meet the situation by devising effective means for cleaning the pipe and keeping it in the condition for best service.

The experiments plotted in Fig. 12, together with more than 300 experiments† recently performed by A. V. Saph, Assoc. Am. Soc. C. E., and the writer, on fifteen seamless drawn brass pipes varying in diameter from $\frac{1}{10}$ in. to 2 ins., with every laboratory facility for extreme accuracy, furnish some remarkably harmonious evidence concerning the loss of head in smooth, continuous pipes.

The simplest formula, as well as the most exact one for such pipes, is of the form $H_f = m\, V^n$, where H_f is the loss of head and V is the velocity. The value of m is obtained directly from the logarithmic plotting by noticing the intercept on the line for $V = 1$. The value of n is equal to the slope of the line drawn through the plotted points.

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* See description by Henry Goldmark, M. Am. Soc. C. E., *Transactions*, Am. Soc. C. E., Vol. xxxviii., p. 279.

† Mr. Saph and the writer hope to be able to present in the near future their experimental data, together with a discussion of the work of others.

Mr. Schoder.

The formulas, of the form $H_f = m\ V^n$, for the four pipes, the data of which are plotted in Fig. 12, are:

14-in.	H_f per 1 000 ft.	$= 0.300\ V^{1.73}$
44 "	" " " "	$= 0.125\ V^{1.73}$
54 "	" " " "	$= 0.0815\ V^{1.73}$
72 " (1897)	" " " "	$= 0.062\ V^{1.73}$
72 " (1899)	" " " "	$= 0.048\ V^{1.94}$

To these* may be added the formula given by Mr. Saph and the writer† for 2.09-in. seamless drawn brass pipe:

$$H_f \text{ per } 1\,000 \text{ ft.} = 2.62\ V^{1.759}$$

At the present time the writer does not desire to comment in detail upon these formulas. However, he would again point out the disparity between the formula for the 1899 Ogden series and the formulas for the other five pipes. Considering the variation in the value of m in these formulas, the evidence of the five sets of experiments, for which the exponents of V are practically the same, shows that m varies inversely as the 1.05ths power of the diameter. This power is the slope of a line obtained from a logarithmic plotting of the diameter and the values of m. It appears from such a plotting that, for the 44-in. pipe, either the losses of head are about 18% higher or the velocities are about 11% lower than would be expected from the indications for the other four pipes. The author himself has expressed surprise at the non-conformity of the results of the 44-in. pipe with those of the 54-in. and 72-in. pipes. It may be said, however, that the data for the 44-in. pipe are consistent among themselves, and the error, if any, is in the nature of a constant factor. Indeed, the author's results plot up on logarithmic paper in a way which compels admiration and gives strong evidence of careful work.

In conclusion, the writer would say that in laboratory work, even when the utmost care is exercised, apparent inconsistencies are often found, but it is nearly always possible either to find the cause or else by many repeated experiments to obtain convincing evidence that unknown, abnormal causes affected certain results. Unfortunately, the practicing engineer has not the time, nor do conditions generally allow such procedure, in the case of large pipes in use. But the evidence was never stronger than now that there are numerous cases where a hydraulic engineer can estimate closely the performance of a pipe line. On the other hand, the number of cases is legion where only rough approximation is justified. The writer feels that it is in the hope that the dividing line may be more clearly marked that the

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* Attention should be called also to the results of Messrs. Williams, Hubbell and Fenkell on a new 12-in. cast iron pipe, given on pages 180 and 181, *Transactions*, Am. Soc. C. E., Vol. xlvii. This line was laid with great care, and the two 1 000-ft. experimental sections were preceded and followed by long stretches of tangent. The values of m and n, in the equation which fits this pipe, fall with remarkable precision where they would be expected in the logarithmic plottings. The equation as given is

$$H_f \text{ per } 1\,000 \text{ ft.} = 0.3233\ V^{1.779}$$

† *Transactions*, Am. Soc. C. E., Vol. xlvii., p. 814.

Mr. Schoder. civil engineer reads with more than passing interest each description of new experiments.

Mr. Saph. A. V. Saph, Assoc. Am. Soc. C. E. (by letter).—The writer has been informed by Mr. E. W. Schoder as to the nature of his discussion on this paper, so that there will be no need of attempting a complete discussion of the results of observations on wood stave pipe by plotting them logarithmically and obtaining expressions for the values of m and n in the general formula $H_f = m\ V^n$. For these quantities, Mr. Schoder obtained $n = 1.73$ for most of the experiments, and $m = \frac{k}{D^{1.05}}$. The last result was quite a surprise, as the writer would have predicted that the loss of head should depend on about the 1.30ths power of the diameter instead of on the 1.05ths. One would naturally be led to think that this would be so, as all discussions in regard to cast-iron pipe would have shown this value, as may be seen from the numerous formulas of the form $H_f = m\ V^n$, which have been proposed in late years.

The writer, therefore, has plotted the observations on wood pipes and has almost checked Mr. Schoder, as far as the value of n is concerned, but would extend the discussion in regard to the manner in which the values of m depend upon the values of the pipe diameter. In order to obtain this relation, the values of m, as taken from a direct logarithmic plotting of the observed results, are themselves plotted on a logarithmic sheet as ordinates with the corresponding diameters as abscissas. The slope of the resulting straight line is the required power of D, and its intercept on the axis ($D = 1$) is the value of the constant k. If, on such a plotting, all the values of m are considered, without any attempt at classifying, the mean line would have a slope of 1.05, but, in drawing such a line, it will be noticed that a number of points are situated at quite a distance from it. Assuming, however, that the n for the experiment on 18-in. pipe is 1.74, we get a value of m which, taken in connection with the m for 14-in. pipe, gives a line having a slope of 1.29—more nearly what the writer believes it should be. The experiments by Mr. Noble considered alone would lead to a higher value, but, including with them the experiments by Messrs. Marx, Wing and Hoskins, and taking a mean line, we have here also a slope of about 1.36. The two lines, however, are widely separated, indicating a large difference in the values of the constant k, which is about 0.360 for the smaller pipes and 0.610 for the larger ones. These values apply for losses of head in feet per 1 000 ft. of length, velocities in feet per second, and diameters in feet.

We may mention in addition, the experiment on 24-in. pipe by Mr. D. C. Henny,* M. Am. Soc. C. E., which is usually accredited to Mr. Gutillius.† Mr. Henny says that the experiment is not reliable, on

* *Journal*, Association of Engineering Societies. Vol. xxi, 1898.

† *Transactions*, Am. Soc. C. E., Vol. xl, 1898, p. 562, footnote.

account of the manner of measuring velocities, but it may be introduced here in order to assist in justifying the classification we have made. For a velocity of 1.147 ft. per second the value of c, in $v = c\sqrt{r\,s}$, was 127 (Kutter $n = 0.0103$). Upon determining the corresponding m (under the assumption $n = 1.74$), we find the experiment to be much farther removed from those on the large pipes than were the experiments by Mr. A. L. Adams, and if proper corrections were made it would probably correspond closely with those on smaller pipes. The writer does not believe that these corrections could possibly be large enough to bring it into the same class with the experiments by Mr. Noble and Messrs. Marx, Wing, and Hoskins. Judging by the value of the Kutter n, the experiment by Mr. Schuyler would also fall into the same class with those on smaller pipes. Mr. Saph.

The writer, therefore, believes that all available experiments on wood pipe fall into two groups, both following the same law as to their dependence on the velocity and the pipe diameter, but differing considerably in the values of the constant k. Even from a consideration of the values of the Kutter n, this division into groups is made necessary, and the same grouping is reached as by the method used. The cause of the differences found is hard to determine. Messrs. Marx, Wing and Hoskins have said that the differences in the value of the Kutter n can hardly be accounted for through a difference in the roughness of the pipe surface, and the same statement applies to the differences in the values of the constant k. Curvature suggests itself, then, as a possible cause. The investigations by Messrs. Williams, Hubbell, and Fenkell* show that the long, easy curves cause greater excess losses of head than sharp ones, beyond a limiting radius which would not occur in wood pipe lines, a fact which has a particular bearing on large wood pipe investigations. The curvature effects, besides depending on the degree of curvature, would also, in a long line of pipe, depend on the ratio of total curved length to total true tangent length. Therefore, in the experiments by Mr. Noble, as well as in all others on wood pipe, it would have been interesting to have had some data in regard to the excess loss due to the curves, in order to account, if possible, for the great difference in experimental results, and also to afford general information in regard to curvature effects.

It will also be noticed in connection with the values given for the velocities, that the velocity in the center ring is always less than that in the adjacent ring. Upon plotting these velocities, a very flat curve results, which bears but little resemblance to cycloids or ellipses. This may be due to the enlargement at the well, but it seems hardly probable that it can be wholly accounted for in this way. If it can be, however, it would lead to the conclusion that velocity curves for both

*Transactions, Am. Soc. C. E., Vol. xlvii, 1902.

Mr. Saph. enlargements and contractions are similar, because similar curves were obtained by Mr. John R. Freeman for nozzles.*

Reference to the plan of the 54-in. pipe shows that Piezometer *A* was situated at the point of tangency of a curve, and that there was only a short length of tangent between Piezometer *A* and the well. Therefore, it would be interesting to know if the individual velocities as measured showed any appreciable effect due to the curve above. The flattened velocity curves might be accounted for in this way, as similar velocity curves are obtained by taking corresponding points from the velocity contour map† presented by Mr. Schoder and the writer in connection with their discussion of the paper by Messrs. Williams, Hubbell and Fenkell. If curvature effects are shown at the well, the averaging of observation to get the velocities in the rings would lead to results somewhat in error. For the same reason, Piezometer *A* would read low and account for that part of the difference between the water heights at Piezometer *A* and the well which has not already been accounted for except through possible errors. However, the full natural effect of the curve might not have shown itself on account of the reversal of curvature above.

Mr. Noble's experiments show careful and intelligent work, and have advanced materially our knowledge of the resistances to the flow of water in wood stave pipes. There is a need, however, for more experiments of the same kind, especially on diameters between 18 ins. and 44 ins., and, when these are performed, it is hoped that the effects of the curves will be investigated.

Mr. Merriman. MANSFIELD MERRIMAN, M. Am. Soc. C. E. (by letter).—The quantity, *b*, which is found in the formulas on pages 504–505‡, does not appear to be due to accidental errors of observation, but probably results from some constant cause. From an inspection of the results given in Fig. 11, it is seen that the highest velocities occurred in the 44-in. pipe, for which the value of *b* is 0.188, and that the lowest velocities occurred in the 14-in. pipe, for which the value of *b* is 0.020, while for the other pipes both the velocities and the values of *b* lie between these limits. This is more clearly shown by Table No. 6.

TABLE No. 6.

Diameter of pipe (inches)......	44	54	72	14
Greatest velocity...............	4.4	4.5	4.7	1.6 ft. per second.
Least velocity..................	3.5	2.3	1.2	0.7 "
Average velocity...............	4.1	3.4	2.5	1.0 "
Value of *b*......................	0.188	0.080	0.081	0.020

* *Transactions*, Am. Soc. C. E., Vol. xxi, 1889.

† *Transactions*, Am. Soc. C. E., Vol. xlvii, p. 301, 1902.

‡ *Proceedings*, Am. Soc. C. E., for August, 1902.

Mr. Merriman.

These values of b, at first sight, appear to have little relation to the diameter of the pipe, but it is plain that they increase with the average velocity under which the observations were made.

Roughly, the four values of b deduced by the author are proportional to the squares of the foregoing average velocities in the four sets of observations, as shown in Table No. 7.

TABLE No. 7.

(Average $V)^2$	16.8	11.6	6.2	1.0
$\frac{1}{100}$ (Average $V)^2$	0.168	0.116	0.062	0.010
Value of b	0.188	0.080	0.081	0.020

Now, as the square of a velocity is closely proportional to the lost head, it is clear that b, for any set of observations, should be approximately proportional to the average head, H, under which that set was made. Several experiments made under high heads should give a higher value of b than several made under low heads. This is seen to be the case with the four series represented graphically in Fig. 10.

A probable reason has occurred to the writer why the systematic errors represented by b appear in the formulas deduced. It is that the piezometer readings do not give the exact hydraulic gradient which corresponds to the mean velocity of flow in the pipe. The piezometers measure the pressures at the circumference of the pipe where losses occur by both sliding and eddying friction. These frictional losses are probably greater than those which prevail for a filament where the velocity is equal to the mean velocity. If so, the hydraulic gradient obtained by taking differences of piezometer readings has a steeper slope than that corresponding to the mean velocity of flow. Hence the losses of head per thousand feet, represented by H, are too great, and it has been shown that they are greater for large friction heads than for small ones. The quantity, b, from this point of view, is a correction to be applied to the observed friction head, H, in order to give the true friction head, $H - b$, which corresponds to the mean velocity, V.

The writer puts forth this hypothesis as a tentative one, only, trusting that it may lead to further discussion. He is not fully convinced that the hypothesis gives the true reason why b appears in the formulas, but that the values of b vary with the average velocity head in the different sets of observations appears to be fully established by the data of the paper.

Using the author's notation, the formula for the mean velocity, V, in a pipe of diameter D, due to a loss of head of H feet per thousand, is

$$V = e\sqrt{D\,(H - b)}.$$

Now, as b^2 is small compared with H, an approximate value of V^2 is

Mr. Merriman. $e^2\ D\ H$, and as it has been shown that b, for these wood pipes, is closely proportional to V^2, an algebraic expression for it is,

$$b = \text{constant} \times e^2\ D H.$$

The quantity b, therefore, turns out to be proportional, both to the friction head, as deduced from the piezometer readings, and to the diameter of the pipe.

The values of b computed from this expression, taking the constant as 0.009, are shown in Table No. 8. A comparison of these with the values deduced by the author shows an agreement which is perhaps sufficiently close to give some support to the hypothesis advanced by the writer.

TABLE No. 8.

Nominal diameter (inches)......	14	44	54	72
Diameter D....................	1.17	3.71	4.52	6.04 ft.
Value of e....................	1.80	1.92	2.09	2.00
Average H.....................	0.30	1.43	0.70	0.31 ft.
$0.009\ e^2\ D H = b$............	0.010	0.176	0.114	0.067
Author's b....................	0.030	0.188	0.080	0.081

Substituting the algebraic expression for b in the foregoing velocity formula, it becomes,

$$V = e \sqrt{D\ (H - 0.009\ e^2\ D H)},$$

in which the quantity, $0.009\ e^2\ D\ H$, may be regarded as a correction to be subtracted from the observed friction head, H, in order to reduce it to the friction head which corresponds with the mean velocity, V.

The single observation made by Mr. A. L. Adams on an 18-in. wood pipe furnishes the data for computing e by the help of the foregoing formula, as all the other quantities are known. Thus, from $V = 3.63$ ft. per second, $H = 1.97$ ft. per thousand, and $D = 1.50$ ft., there is found $e = 2.18$, and then $0.009\ e^2\ D\ H = 0.128$, whereas,

$$V = 2.18 \sqrt{D\ (H - 0.128)} = 2.67 \sqrt{H - 0.128}$$

is the formula for this wood pipe under the given data. Had the observation been taken under a smaller head, the value of b would have been smaller. The interpolated values for this case given by the author on page 505*, are $e = 1.82$ and $b = 0.041$. The above discussion indicates, however, that interpolation in this case is not fully justified, for, although 18 ins. lies between 14 and 44 ins., the mean velocity and the friction head for the 18-in. pipe are outside of the limits of those observed on the other two pipes, as is seen by Fig. 11.

The values of the coefficient, e, deduced by the author, generally increase with the diameter of the pipe. This is in agreement with the law usually found to hold for pipes and conduits. How e varies with H, however, is not apparent from the data. According to Kutter's formula, e should increase with H when the hydraulic radius of

* *Proceedings*, Am. Soc. C. E., for August, 1902.

the pipe is less than one meter, and this is the case with all these wood pipes. According to Bazin's formula, e should be independent of H. It is clear that the influence of H upon e will be much less than that of D. The writer has made several attempts to deduce a formula for e in terms of H and D, from the author's data, but they have not been sufficiently successful to record here. Probably the different degrees of roughness of the pipes obscure the influence of the different heads. For the present and immediate future the values of e deduced by the author in his interesting and valuable paper must be used for wood pipes, but the present discussion indicates that the probable value of the quantity, b, may advantageously be computed from Mr. Merriman.

$$b = 0.009\, e^2\, D\, H.$$

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PAPERS AND DISCUSSIONS.

A PROPOSED NEW TYPE OF MASONRY DAM.

Discussion.*

By George L. Dillman, M. Am. Soc. C. E.

Mr. Dillman. George L. Dillman, M. Am. Soc. C. E. (by letter).—Discussion has developed the following criticisms:

1st. The mass is not sufficient.—Mr. Parsons says that this is on account of stability against sliding and overturning; Mr. Abbott says it is on account of difficulties in making the dam tight.

According to the generally accepted laws of friction (which are wrong, but which need not be discussed here), any decrease in mass decreases the factor against sliding, but it is distinctly against elementary engineering to say of stability against overturning: "The important factor is to have mass, rather than little mass mathematically placed." If mass alone is to be considered, what difference does the shape make? The "standard types" might be built upside down.

Tightness is considered further on.

2d. The stresses are not determinable.—The stresses may not be measurable, but they are more nearly determinable than stresses in a uniform-sectioned dam, because the point where the water is cut off is more nearly known.

The internal stresses caused by the setting of the concrete masonry are probably not different from a uniform-sectioned dam. Were these large enough for danger, it is certain that each buttress would have to stand for itself, as the thin part of the wall would transmit no large strain to the next buttress.

* Continued from September, 1902, *Proceedings*. See April, 1902, *Proceedings* for paper on this subject by George L. Dillman, M. Am. Soc. C. E.

As for external forces, weight will act through the center of gravity more certainly than in a dam in which water penetration is unknown. The same can be said of the center and direction of water pressure. It should be noted that the unit can be considered from center to center of arches as well as from center to center of buttresses. Mr. Dillman.

3d. The plan is difficult to execute and expensive to build.—This criticism is made most frequently by those who speak of a cut-stone face. The writer has no idea of using cut stone or even coursed masonry in a dam, except for coping and trimming. Rubble and concrete are the materials for such work to-day. Even rubble is getting to be inexpedient, except to save cement when the haul is expensive.

The curved surface can be developed into a plane, so that either the frames or the lagging of the forms can be straight lumber. For dams of considerable size, frames should probably be up and down, and the lagging bent to these straight frames. For lower dams, when the curvature is sharper, probably horizontal frames with up and down lagging might be better. In either case, the cost is not excessive, and the parabolic is as cheap as any other curved form.

The writer is engaged now in putting in some concrete dam work in which he is using cylindrical, truncated-conical, elliptical and parabolic forms, and, except for a few minutes with his carpenter foreman on each new shape, cannot see that there is any trouble, or much difference in cost between them and straight forms. There is no more lumber used than would be used in a broken surface approximating the curve. The cost of band-sawing the frames is insignificant, and a yard of concrete is rammed against a curved form as cheaply as against a straight one.

4th. A thin wall cannot be made tight.—Mr. Fuller has replied to this criticism by saying: "It would probably be easier to make the thin wall tight than the thick one." That has also been the writer's experience.

There is another consideration: If a dam cannot be made tight at its up-stream face, it is a mistake to tighten it at all. The up-stream face, if not tight, should be the most nearly tight surface. All water passing it should be allowed to escape without exerting further pressure. The penetration of water to some tighter surface is the principal source of doubt in dam stresses. Such penetration practically shifts the center of gravity and the direction of water pressure.

5th. It is not the most economical of its class.—No such claim was made; but the Ogden Dam, with a steel face anchored to bed-rock or massive concrete to stand tension, is hardly in the same class. Economy is not the best point in the proposed type. Increased factors of safety, and chance for inspection and repair are of much more importance.

The dimensions, batters, curves, specific gravity of the masonry, and the allowable strain used, were adopted for purposes of fair com-

Mr. Dillman. parison, simplicity and the avoidance of certain criticisms. The general type of buttressed wall can be cheapened materially beyond the particular one analyzed.

6th. It is not new.—It seems to the writer that finding out what has been done, and, therefore, with certainty what can be done, is fully as important to successful engineering as new discoveries. Besides, it was absolutely new to the writer when, in the prosecution of work, he discovered it. It seemed new to some of his friends to whom he showed it. It could not have been "readily found elsewhere," or the Publication Committee of the Society would not have published it.

MEMOIRS OF DECEASED MEMBERS.

NOTE.—Memoirs will be reproduced in the Volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Secretary prior to the final publication.

MILTON GROSVENOR HOWE, M. Am. Soc. C. E.*

DIED JUNE 19TH, 1902.

Milton Grosvenor Howe was born at Methuen, Massachusetts, on August 16th, 1834.

He was graduated from Dartmouth College in 1854, having taken both the academic and scientific courses. His first work was on a survey for a road which was projected to run north from Saratoga, New York, through the Adirondacks to Sackett's Harbor. The surveying party, in charge of the late John Newell, M. Am. Soc. C. E., spent a winter in the mountains, but the road was never built.

In 1855 Mr. Howe went to Illinois, and was employed on the Illinois Central Railroad until the panic of 1857 caused the stoppage of all construction. His next work was in Iowa, but the stringency in the money market made business dull, and he found himself at the beginning of winter without occupation. Having a fondness for study, he decided to put in the time reading law, and so rapidly did he acquire knowledge that in the spring he passed the examinations and was given a license to practice. He was devoted to engineering, however, and, believing that greater opportunities existed in the Southwest, besides desiring a warmer climate, he went to Texas in the fall of 1859, and entered the service of the Houston and Texas Central Railroad.

At the beginning of the war he enlisted in the Army of the Confederacy as a volunteer in Company A of the Twenty-sixth Texas Cavalry, De Bray's Regiment. Within a year he was transferred to the Engineering Corps and given the rank of Captain. He was an ardent exponent of the cause of the South, and it was by his skill as an engineer and inventor that two of the five cannon used so effectively in the battle of Sabine Pass were improvised.

At the close of the war Captain Howe again entered the service of the Houston and Texas Central Railroad, and held the positions of Chief Engineer, General Superintendent and Division Superintendent.

In 1885 he was made Receiver of the Houston, East and West Texas Railroad. After this road, under his able management, had passed from under the Receivership, he became Vice-President and General

* Memoir prepared by the Secretary from information furnished by Mrs. M. G. Howe.

Manager. In 1897, on account of poor health, he retired from active work. In 1899 Captain Howe was appointed Chief Engineer of the Houston and Texas Central Railroad, but resigned within the year, owing to poor health.

Many of Captain Howe's best efforts were directed toward advancing the interests of the City of Houston, of which he was an alderman for six years.

In 1873 he was married to Miss Jessie W. Briscoe, who, together with one son, Mr. Milton Howe, of the Engineering Department of the Houston and Texas Central Railroad, survives him.

Mr. Howe was elected a Member of the American Society of Civil Engineers on October 16th, 1872. He was appointed a Director on October 21st, 1901, to fill the unexpired term of the late George A. Quinlan, but at that time was in such poor health that he had to decline the appointment.

MORITZ LASSIG, M. Am. Soc. C. E.*

Died January 7th, 1902.

Moritz Lassig was born in Rochlitz, Saxony, on January 23d, 1831. He attended the Architectural School in Chemnitz, and, having completed his studies there, came to America, where he arrived in the spring of 1851. In the fall of the same year he settled in Chicago, having accepted a position as Engineer and Superintendent with the firm of L. B. Boomer and Company, later the American Bridge Company, of Chicago. This position he held until 1853. From 1871 to 1881 he was engaged in designing and constructing bridges throughout the West.

In the year 1876 he established his own shop on South Clark Street, near Sixteenth Street. The present shop, at Clybourn and Wrightwood Avenues, at which he achieved his principal success as a bridge builder, was founded about 1885. In 1881 he formed a partnership with John P. Alden, under the names Lassig and Alden Bridge and Iron Works of Chicago, and Alden and Lassig Bridge and Iron Works of Rochester, New York. Mr. Lassig was active as the President and guiding spirit of the Lassig Bridge and Iron Works until the fall of 1900, when he sold his interests to the American Bridge Company and severed his connection with the firm.

He was on the eve of departure for Europe, having made all arrangements to leave Chicago on January 8th, but was overtaken suddenly by death. His remains have been interred at Heidelberg, Germany.

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* Memoir prepared by the Secretary from information furnished by Mr. Henry Bartholomay, Jr., and from papers on file at the Society House.

His widow, Marie Lassig, and two married daughters, Mrs. Emma Bartholomay and Mrs. Ida Olinger, survive him.

Moritz Lassig was elected a Member of the American Society of Civil Engineers on April 2d, 1884. He was also a Member of the Western Society of Engineers, of the Technical Club, Concordia Masonic Lodge, Germania Männerchor, and the Chicago Schuetzen Verein.

OSCAR F. WHITFORD, M. Am. Soc. C. E.*

Died May 21st, 1902.

Oscar F. Whitford, third child and second son of Earl Hartwell and Asenath (Palmer) Whitford, was born on July 15th, 1833, in the Town of Northumberland, Saratoga County, New York. He lived on his father's farm until he grew to manhood, attending district schools, Schuylerville Academy, and a preparatory school at Charlotteville, New York.

After being graduated from Union College, Schenectady, New York, in the classical course, in 1858—having taken a part of the engineering course as extra, under Professor Gillespie—he went to Mississippi, where he taught school and sold machinery until 1861, when he returned to Union College and took a post-graduate course in chemistry, receiving the degree of A.M.

In 1862 he was a volunteer in the United States Army for four months, to escort and protect emigrants crossing the Western Plains and Rocky Mountains.

After this service he engaged in gold mining enterprises in California and Idaho. He left this work to accept the Chair of Mathematics and Civil Engineering in the People's College at Havana, New York, now Montour Falls.

For a period of ten years, up to 1876, he was employed on the New York State Canals, in the Engineering Department, in charge of work, first on the Chenango Canal and afterward on the Erie Canal.

Leaving this service he engaged in lead mining in Missouri for two years, after which he was an engineer on the construction of the Southern Kansas Railroad for a year.

The following year, 1880, was taken up in testing cements and in the duties of general storekeeper for the Plattsmouth Bridge.

Silver and gold mining in Colorado and Mexico occupied his attention from 1881 to 1887. During the last two years of this period he was Superintendent of the Santa Barbara Mines at Chihuahua.

* Memoir prepared by S. J. Fields, M. Am. Soc. C. E.

From 1888 to 1890 he was employed as Engineer for contractors on railroads for the Chilean Government. Returning to the United States he was engaged as Assistant Engineer on the Michigan Central Railroad, then as General Inspector in the Bureau of Engineering of the City of Buffalo, New York, up to 1898. From that year up to the time of his death he was occupied with various engineering enterprises.

He was a man of kind disposition and remarkably even temperament. He was loyal to his friends, kind and considerate to his subordinates.

He was unmarried, and is survived by two brothers and a sister.

Mr. Whitford was elected a Member of the American Society of Civil Engineers on December 6th, 1871, and contributed to the *Transactions* a paper* entitled "Closing Breaks in Canals, under Difficulties."

* *Transactions*, Am. Soc. C. E., Vol. ii, p. 161.

PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS.

(INSTITUTED 1852.)

VOL. XXVIII. No. 9.

NOVEMBER, 1902.

Edited by the Secretary, under the direction of the Committee on Publications.

CONTENTS.

NEW YORK 1902.

American Society of Civil Engineers.

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Vice-Presidents.

Term expires January, 1903:	*Term expires January, 1904:*
HENRY S. HAINES,	CHARLES C. SCHNEIDER,
GEORGE H. BENZENBERG,	JOHN R. FREEMAN.

Secretary, CHARLES WARREN HUNT.

Treasurer, JOSEPH M. KNAP.

Directors.

Term expires January, 1903:	*Term expires January, 1904:*	*Term expires January 1905:*
JOHN F. O'ROURKE,	JOSIAH A. BRIGGS,	RICHARD S. BUCK,
HENRY B. SEAMAN,	GEORGE F. SWAIN,	GEORGE H. PEGRAM,
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WILLIAM H. KENNEDY.	FRANK C. OSBORN.	JAMES L. FRAZIER.

Assistant Secretary, T. J. McMINN.

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THE PRESIDENT OF THE SOCIETY IS *ex-officio* MEMBER OF ALL COMMITTEES.

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RICHARD S. BUCK,	JOSEPH RAMSEY, JR.,	EMIL KUICHLING,
WILLIAM J. WILGUS.	FRANK C. OSBORN.	CHARLES WARREN HUNT.

Special Committees.

ON UNIFORM TESTS OF CEMENT:—George S. Webster, George F. Swain, Alfred Noble, W. B. W. Howe, Louis C. Sabin, S. B. Newberry, Clifford Richardson, Richard L. Humphrey, F. H. Lewis.

ON RAIL SECTIONS:—G. Bouscaren, C. W. Buchholz, S. M. Felton, Robert W. Hunt, John D. Isaacs, Richard Montfort, H. G. Prout, Joseph T. Richards, Percival Roberts, Jr., George E. Thackray, Edmund K. Turner, William R. Webster.

The House of the Society is open from 9 A.M. to 10 P.M. every day, except Sundays Fourth of July, Thanksgiving Day and Christmas Day.

HOUSE OF THE SOCIETY—220 WEST FIFTY-SEVENTH STREET, NEW YORK.

TELEPHONE NUMBER, - - - - 533 Columbus.
CABLE ADDRESS, - - - - - "Ceas, New York."

Vol. XXVIII. NOVEMBER, 1902. No. 9.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PROCEEDINGS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

SOCIETY AFFAIRS.

CONTENTS:

MINUTES OF MEETINGS.

OF THE SOCIETY.

November 5th, 1902.—The meeting was called to order at 8.40 P. M., Rudolph Hering, M. Am. Soc. C. E., in the chair; Charles Warren Hunt, Secretary; and present, also, 98 members and 18 visitors.

The minutes of the meetings of October 1st and 15th, 1902, were approved as printed in *Proceedings* for October, 1902.

A paper entitled "The Footbridge for Building the Cables of The New East River Bridge," was presented by the author, Isaac Harby, Jun. Am. Soc. C. E., and illustrated with lantern slides. The subject was discussed by Wilhelm Hildenbrand, M. Am. Soc. C. E.

Ballots for membership were canvassed, and the following candidates were elected:

As MEMBER.

ULYSSES B HOUGH, Kellogg, Idaho.

As ASSOCIATE MEMBERS.

HERBERT JAMES CHAMBERS, New York City.
FRED RUFUS DAVIS, Juneau, Pa.
LEONARD HENRY DAVIS, Sault Ste. Marie, Ont., Canada.
ALVAH BENJAMIN DIEHR, Memphis, Tenn.
WILLIAM HALE HAM, New York City.
WINFRED DEAN HUBBARD, Concord, Mass.
JOEL JUK PEMOFF, New York City.
JOSEPH JEANES WALKER, New York City.

The Secretary announced the election of the following candidates by the Board of Direction on November 4th, 1902:

As JUNIORS.

GEORGE JACOB DAVIS, Jr., Washington, D. C.
EDUARDO ORTIZ, Mexico City, Mexico.
GEORGE THEOPHANES PARASCHOS, Constantinople, Turkey.
EDMUND MOORE RHETT, Washington, D. C.
FRANK MAURICE WEAVER, Philadelphia, Pa.

The Secretary announced the death of GEORGE HENRY MENDELL, elected Member September 6th, 1876; died October 19th, 1902.

Adjourned.

November 19th, 1902.—The meeting was called to order at 8.40 P. M., Emil Kuichling, Director, Am. Soc. C. E., in the chair; Chas. Warren Hunt, Secretary; and present, also, 112 members and 11 guests.

A paper, entitled, "An Alternative Line for the Nicaragua Canal, and a Proposed New Method of Dam Construction," by J. Francis Le Baron, M. Am. Soc. C. E., was presented by the Secretary, who also read a communication on the subject from L. M. Haupt, M. Am. Soc. C. E., and exhibited a set of lantern slides, illustrative of the Nicaragua Canal, sent by H. de B. Parsons, M. Am. Soc. C. E.

The subject was discussed by Messrs. Alfred Noble, P. C. Hains, Edward P. North and Edward Wegmann.

The Secretary announced the death of JOHN WOODBRIDGE DAVIS, elected Associate June 3d, 1885; died November 7th, 1902.

Adjourned.

OF THE BOARD OF DIRECTION.

(Abstract.)

November 4th, 1902.—Vice-President Haines in the Chair; Charles Warren Hunt, Secretary; and present, also, Messrs. Briggs, Croes, Jackson, Knap, Kuichling, Pegram, Seaman and Swain.

The Secretary was instructed to prepare and publish an additional Catalogue of the Library of this Society, covering additions to the Library since the first Catalogue was issued, about 2½ years ago.

On the invitation of the Managers and Faculty of Swarthmore College, Henry B. Seaman, M. Am. Soc. C. E., was appointed to represent this Society at the inauguration of Joseph Swain, LL.D., as President of Swarthmore College, on November 15th, 1902.

The Secretary reported the receipt, through the executor of Herbert Steward, deceased, of $1 940, to be known as the Herbert Steward Library Fund. The income of this fund is to be used annually for the purchase of books, etc., for the Library.

The appointment of a Committee was authorized to take up the question of an exhibit, in the name of the Society, at the World's Fair, St. Louis, 1904; and also to take such action as may be deemed necessary in interesting members of the Society in general in an engineering exhibit.

Applications were considered and other routine business transacted.

Five candidates for Junior were elected.

Adjourned.

ANNOUNCEMENTS.

The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

MEETINGS.

Wednesday, December 3d, 1902.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and a paper by A. C. Dennis, M. Am. Soc. C. E., entitled "Virtual Grades for Freight Trains," will be presented for discussion.

This paper is printed in this number of *Proceedings*.

Wednesday, December 17th, 1902.—8.30 P. M.—At this meeting there will be an informal discussion on the topic, "The Sanitary Disposal of Municipal Refuse." The discussion will be opened by Rudolph Hering, M. Am. Soc. C. E. Contributions to this discussion, either at the meeting or in writing, are invited.

ANNUAL MEETING.

The Fiftieth Annual Meeting will be held at the Society House, January 21st and 22d, 1903. The Business Meeting will be called to order at 10 o'clock on Wednesday morning. The annual reports will be read, officers for the ensuing year elected, members of the Nominating Committee appointed, and other business transacted.

The arrangements for excursions and entertainments will be announced later.

NOMINATING COMMITTEE.

The Constitution provides that at the Annual Meeting of each year, seven Corporate Members, not officers of the Society, one from each of the geographical districts, into which the Society is divided for this purpose, shall be appointed by the meeting to serve for two years.

The usual blank request for suggestions as to representatives of each district, for presentation to the meeting, will soon be mailed to Corporate Members.

ACCESSIONS TO THE LIBRARY.

From October 8th to November 11th, 1902.

DONATIONS.*

THE DESIGN OF SIMPLE ROOF-TRUSSES IN WOOD AND STEEL.

With an Introduction to the Elements of Graphic Statics. By Malverd A. Howe, M. Am. Soc. C. E. Cloth, 9 x 6 ins., 8 + 129 pp., illus. New York, John Wiley & Sons, 1902. $2.00.

The author states that the object in writing this work has been to bring together in small compass all the essentials required in properly designing ordinary roof trusses in wood and steel. The tables giving the properties of standard shapes are based upon sections rolled by the Cambria Steel Company. The chapter headings are: General Principles and Methods; Beams and Trusses; Strength of Materials; Roof-Trusses and their Design; Design of a Wooden Roof-Truss; Design of a Steel Roof-Truss; Tables. There is an index of five pages.

THEORY OF STEEL-CONCRETE ARCHES, AND OF VAULTED STRUCTURES.

By William Cain, M. Am. Soc. C. E. Second Edition, Thoroughly Revised. Cloth, 6 x 4 ins., 86 pp., illus. New York, D. Van Nostrand Company, 1902. 50 cents. (Donated by the Author.)

The preface states that, in this revision, the author has availed himself of the opportunity to give a complete solution of the elastic arch of variable section. The arch of steel and concrete combined is taken up in detail to illustrate the general graphical treatment. The method to follow for other arches, as those of steel, stone or concrete, is at once apparent from the general solution. The aim throughout has been to give a clear analysis of principles involved, a knowledge of the principles of the equilibrium polygon being alone assumed. This book, although independent of the author's other works on Arches, really supplements them, since in "Theory of Voussoir Arches," the elastic arch of constant section is alone treated, and in "Theory of Solid and Braced Elastic Arches," the arch of variable section is very briefly considered without a completely worked out example. This work then deals especially with the most complicated case, and it is believed that a thoroughly practical solution is offered. The chapter headings are: Arches of Variable Section under Vertical Loads; Culverts and Tunnel Arches; Groined and Cloistered Arches; Domes of Masonry.

THE ELECTRICAL CATECHISM.

533 Plain Answers to 533 Practical Questions about Electrical Apparatus. Compiled from the Regular Issues of *Power*. Cloth, 9 x 6 ins., 210 pp., illus. New York, Hill Publishing Company, 1902. $2.00.

In preparing the subject matter of this book the author's aim has been to discuss only such branches of electrical work as may be considered to come within the range of the average central station or isolated plant engineer. On this account he has not endeavored to cover the entire electrical field, but rather to make the treatment of principles and practice in what might be termed the "heavier" branches of electrical engineering more exhaustive than is usual in a work of this kind. No originality is claimed for the subject matter, but an effort has been made to present the expository matter in logical sequence and in clear, every-day phraseology. Parts of the matter here presented have appeared in serial form in *Power;* such portions have been revised to bring them up to date wherever necessary. There is an index of six pages.

ARMATURE WINDINGS OF DIRECT CURRENT DYNAMOS.

Extension and Application of a General Winding Rule. By E. Arnold. Translated from the Original German by Francis B. De Gress. Cloth, 9 x 6 ins., 6 + 124 pp., illus. New York, D. Van Nostrand Company, 1902. $2.00.

The translator states in his preface that Professor Arnold's "Ankerwicklungen," in which is given his general formula for the design of direct current armature windings, has been considered of sufficient importance to be translated and published in the

* Unless otherwise specified, books in the list have been donated to the Library by the Publisher.

present form. Many of the designs shown by him are of historic interest only, but the principle expressed is fundamental, and of value to the engineer or designer, and no attempt has been made to go beyond the subject as treated in his book. The Contents are: Methods of Connecting Inductors; Closed-Coil Windings; Ring Armature Windings; Drum Windings; Disk Armature Windings; Open-Coil Windings.

ELECTRICAL AND MAGNETIC CALCULATIONS.

For the Use of Electrical Engineers and Artisans, Teachers, Students, and all others interested in the Theory and Application of Electricity and Magnetism. By A. A. Atkinson. Cloth, 7 x 5 ins., 7 + 310 pp., illus. New York, D. Van Nostrand Company, 1902. $1.50.

It is stated in the preface that this work, both in plan and material, is the outgrowth of several years of experience in teaching young men the rudiments of electricity. A large part of the matter was prepared expressly as an introduction to a course in electrical engineering; since there was nothing published covering the topics found desirable, and making use of the method herein used. In this volume several processes are brought together wherever possible under a single broad principle, which is then expressed by means of a formula. Through a step-by-step process, principles and formulas are evolved from facts and principles already understood. After the law has been clearly developed, and has been given the most concise, easily remembered and convenient working form, the method of induction gives way to that of deduction. A series of examples is then worked out illustrating the application of the principle, and giving familiarity with its processes. At the end of the chapters are also lists of original problems for drill in the mastery of the principles and their applications. The chapter headings are: Explanation of Units; Relation of Quantities; General Laws of Resistance; Electrical Energy; Alternating Currents; Wiring for Light and Power; Batteries; Magnetism; Relation of Magnetic Quantities; The E. M. F. of Dynamos and Motors; Calculation of Fields; Elements of Dynamo Design. There is an index of ten pages.

ALTERNATING-CURRENT MACHINES:

Being the Second Volume of Dynamo Electric Machinery; its Construction, Design, and Operation. By Samuel Sheldon, M. Am. Inst. E. E., and Hobart Mason, Assoc. Am. Inst. E. E. Cloth, 8 x 5 ins., 4 + 259 pp., illus. New York, D. Van Nostrand Company, 1902. $2.50.

The preface states that this book, like its companion volume on Direct Current Machines, is primarily intended as a text-book for use in technical educational institutions. It is hoped and believed that it will also be of use to those electrical, civil, mechanical, and hydraulic engineers who are not perfectly familiar with the subject of Alternating Currents, but whose work leads them into this field. It is furthermore intended for use by those who are earnestly studying the subject by themselves, and who have previously acquired some proficiency in mathematics. It is believed that one who has mastered the first four chapters of this book will be able to solve any practical problem concerning the relations which exist between power, electro-motive forces, currents, and their phases in series or multiple alternating-current circuits containing resistance, capacity, and inductance. The next four chapters are devoted to the construction, principle of operation, and behavior of the various types of alternating-current machines. Only American machines have been considered. A large amount of alternating-current apparatus is used in connection with plants for the long-distance transmission of power. This subject is treated in the ninth chapter. The last chapter gives directions for making a variety of tests on alternating-current circuits and apparatus. There is an index of seven pages.

ELECTRICAL MOTOR INSTALLATIONS.

A Book for Factory Owners and Other Users of Steam Power. By F. J. A. Matthews, A. M. I. E. E. Boards, 8½ x 5½ ins., 157 pp., illus. The Scientific Publishing Co., Manchester. 2 shillings, 6 pence net.

The preface states that this small book is not intended in any way for the electrical engineer, but is essentially written for users of power who may be desirous of increasing the efficiency of their works. The definitions are given in the plainest manner and in a way in which they can be easily grasped. They may not be in all cases scientifically and absolutely correct, but they are what may be termed commercially correct. The contents are: Introductory; Advantages of Electric Transmission; Definitions and Functions; Typical Types of English Motors; Starting Switches and Other Accessories; Devices for Speed Variation; Some Examples of Motor Installations; Attention and Maintenance. There is an index of three pages.

MECHANICS—PROBLEMS FOR ENGINEERING STUDENTS.

By Frank B. Sanborn. Cloth, 8 x 6 ins., 155 pp., illus. New York, The Engineering News Publishing Company, 1901. $1.50.

The preface states that this book contains many problems similar to those found in text-books; but, besides, many have been developed from actual engineering conditions. The author's object has been to correlate more closely these every-day practical examples with the important subjects in Mechanics. From the author's experience as student, engineer in practice, and college instructor, he is convinced that the main object of a course in Mechanics should be to prepare the students to solve its problems. Therefore he has endeavored to make these problems—five hundred in number—fulfil the requirements for thorough and interesting instruction. At the beginning of each important section of the book one problem is solved so as to explain the method of solving similar problems and to serve as a guide for solutions to be put in note-books. The problems have been arranged under the following heads: I. Work—Foot-Pounds; Horse-Power; Energy; II. Force—Forces Acting at a Point; Moments for Parallel Forces; Couples; Stresses; Center of Gravity; Friction; III. Motion—Uniform Acceleration; Relative Velocity; Distance, Velocity, Friction, Angle of Inclination; Projectiles; Pendulums; Impact. There is an index of fifteen pages.

AN OUTLINE OF THE METALLURGY OF IRON AND STEEL.

By A. Humboldt Sexton. Cloth, 9 x 6 ins., 6 + 620 + 13 pp., illus. The Scientific Publishing Company, Manchester, 1902. 16 shillings net.

The preface states that this work has been prepared to meet the need for a book which, in one volume of moderate size, covers the whole field of the metallurgy of iron and steel. The book has grown somewhat beyond the size contemplated at the outset, but still cannot be regarded as being more than an outline. The iron and steel industry has developed so rapidly within the last few years, and the literature has become so voluminous, that it has been a matter of extreme difficulty to decide exactly what to include and what to leave out. A greater difficulty has been the apportioning of space to the different branches of the subject according to the importance of each, but the author states that he hopes he has kept somewhat near a fair division. The chapter headings are: Introductory; Sources of Iron; Pig Iron; Preparation of Materials for the Smelter: Chemistry of the Blast Furnace; Thermal Phenomena of the Blast Furnace; The Blast Furnace; The Air Supply; The Hot Blast; Blast Furnace Slag; Calculating Charges; Construction of the Blast Furnace; Blast Furnace Practice; Utilization of By-products; History of Pig Iron; The Foundry; Malleable Iron; Puddling; Other Methods of Preparing Malleable Iron; The Forge and the Mill; Steel; Production of Steel Direct from the Ore and from Malleable Iron; Production of Steel by Partial Decarburization of Pig Iron; The Bessemer Process; Chemistry of the Bessemer Process; Thermal Phenomena of the Bessemer Blow; Working the Bessemer Process; Bessemer Plant; The Basic Bessemer Process; Plant for the Basic Bessemer Process; Modifications of the Bessemer Process; Historical Notes on the Bessemer Process; The Siemens or Open-hearth Process; The Siemens Process: Plant; The Basic Open-hearth Process; Modifications of the Open-hearth Process; Appliances Applicable to All Processes; Working Mild Steel; Casting Mild Steel; After Treatment of Iron and Steel; Special Steels; Structure of Iron and Steel; Testing Iron and Steel; Rusting and Protection of Iron and Steel.

AMERICAN MINING CODE:

Embracing the United States, State, and Territorial Mining Laws, and the General Land Office Regulations. Fourteenth Edition. By Henry N. Copp. Paper, 9 x 6 ins., 4 + 183 pp. Washington, D. C., Copp & Co., 1902. 50 cents.

This work gives the mining laws and general land office regulations of the United States, and also the State and Territorial mining laws, and the revised and amended mining regulations for Canada and the Northwest Territories. Copies of the necessary forms, notices, affidavits, certificates, bonds, agreements, etc., are also given.

DES INGENIEURS TASCHENBUCH.

Herausgegeben vom Akademischen Verein "Hütte." Achtzehnte, Neu Bearbeitete Auflage. 2 vol. Leather, 7 x 5 ins., illus. Berlin, Wilhelm Ernst & Sohn, 1902. 16 marks.

It is stated in the preface that the present edition has been enlarged and revised on a scientific basis. Corresponding to the extended knowledge of science in all branches of technology, the separate sections of the book have become more inclusive. Particularly to be noted is the section "Wärme einschliesslich der Mechanik der Gase und

Dämpfe," which has been completely revised; also Turbinen, Lasthebemaschine, Vermessungskunde, Schiffbau. The sections "Verbrennungsmotoren" have been introduced in place of the former "Gasmaschinen," which represented the first attempt at a theoretical handling of this difficult subject. The Contents are: Mathematik; Mechanik; Wärme einschliesslich der Mechanik der Gase und Dämpfe; Festigkeitslehre; Stoffkunde; Maschinenteile; Kraftmaschinen; Arbeitsmaschinen; Vermessungskunde; Hochbau; Wasserversorgung; Städteentwässerung; Lüftung und Heizung; Strassenbau; Statik der Baukonstruktionen; Brückenbau; Schiffbau; Eisenbahnwesen; Eisenhüttenkunde; Electrotechnik; Gasfabrikation; Anhang. There is an index of fifteen pages.

THE FOUNDATIONS OF GEOMETRY.

By David Hilbert. Authorized Translation by E. J. Townsend. Cloth, 8 x 5½ ins., 7 + 132 pp. Chicago, The Open Court Publishing Company, 1902. $1.00 net.

The preface states that the material contained in this translation was given in substance by Professor Hilbert as a course of lectures on Euclidean geometry at the University of Göttingen during the winter semester of 1898-99. As a basis for the analysis of our intuition of space, Professor Hilbert commences his discussion by considering three systems of things which he calls points, straight lines, and planes, and sets up a system of axioms connecting these elements in their mutual relations. The purpose of his investigations is to discuss systematically the relations of these axioms to one another and also the bearing of each upon the logical development of Euclidean geometry. This development and discussion of the foundation principles of geometry is not only of mathematical but of pedagogical importance. The Contents are: The Five Groups of Axioms; The Compatibility and Mutual Independence of the Axioms; The Theory of Porportion; The Theory of Plane Areas; Desargue's Theorem; Pascal's Theorem; Geometrical Constructions Based upon the Axioms I-V.

ON THE STUDY AND DIFFICULTIES OF MATHEMATICS.

By Augustus De Morgan. Second Reprint Edition. Cloth, 8 x 5¼ ins., 6 + 288 pp., por. Chicago, The Open Court Publishing Company, 1902. $1.25 net.

It is stated in the preface of the original edition that in compiling the pages of this book, the author's object has been to notice particularly several points in the principles of algebra and geometry which have not obtained their due importance in elementary works on these sciences. The author does not hold himself responsible for the contents of this treatise, further than for the manner in which they are presented, as most of the opinions here maintained have been found in the writings of eminent mathematicians. The editor of the present edition states that the original treatise, which was published by the Society for the Diffusion of Useful Knowledge and bears the date 1831, is now practically inaccessible, and is marred by numerous errata and typographical solecisms, from which, it is hoped, the present edition is free. References to the mathematical textbooks now out of print have either been omitted or supplemented by the mention of more modern works. The few notes which have been added are mainly bibliographical in character, and refer, for instance, to modern treatises on logic, algebra, the philosophy of mathematics and pangeometry. The Contents are: Introductory Remarks on the Nature and Objects of Mathematics; On Arithmetical Notation; Elementary Rules of Arithmetic; Arithmetical Fractions; Decimal Fractions; Algebraical Notation and Principles; Elementary Rules of Algebra; Equations of the First Degree; On the Negative Sign, etc.; Equations of the Second Degree; On Roots in General, and Logarithms; On the Study of Algebra; On the Definitions of Geometry; On Geometrical Reasoning; On Axioms; On Proportion; Application of Algebra to the Measurement of Lines, Angles, Proportion of Figures, and Surfaces. There is an index of four pages.

ESSAYS ON THE THEORY OF NUMBERS.

I. Continuity and Irrational Numbers. II. The Nature and Meaning of Numbers. By Richard Dedekind. Authorized translation by Wooster Woodruff Beman. Cloth, 8 x 5½ ins., 115 pp. Chicago, The Open Court Publishing Company, 1901. 75 cents net.

In this work the author has endeavored to establish a really scientific foundation for arithmetic, in order to find a purely arithmetic and perfectly rigorous basis for the principles of infinitesimal analysis. The chapter headings are: Properties of Rational Numbers; Comparison of the Rational Numbers with the Points of a Straight Line; Continuity of the Straight Line; Creation of Irrational Numbers; Continuity of the Domain of Real Numbers; Operations with Real Numbers; Infinitesimal Analysis; Systems of Elements; Transformation of a System; Similarity of a Transformation, Similar Systems; Transformation of a System in Itself; The Finite and Infinite: Simply Infinite Systems, Series of Natural Numbers; Greater or Less Numbers; Finite and Infinite Parts of the Number-Series; Definition of a Transformation of the Number-Series by Induction; The Class of Simply Infinite Systems; Addition of Numbers; Multiplication of Numbers; Involution of Numbers; Number of the Elements of a Finite System.

CITY ROADS AND PAVEMENTS SUITED TO CITIES OF MODERATE SIZE.

By William Pierson Judson, M. Am. Soc. C. E., M. Inst. C. E. Second Edition, Revised and Enlarged. Cloth, 9 x 6 ins., 195 pp., illus. New York, The Engineering News Publishing Co., 1902. (Donated by the author.) $2.00.

The local features of the first edition, having served their purpose, have been omitted in this edition, and modifications have been made to show the present applications of general methods, some of which have changed since 1894. The most marked change during the past eight years has been in the increased use of crushed stone for roadways of macadam and of telford construction, on the improved streets of villages and cities. The grade of a city street being usually a fixed condition and not a theory, it is often difficult to decide as to the best pavement for a fixed steep grade in a given climate, or how steep a grade will give good results with a given pavement. Tables of actual instances are given, in order that engineers may know where to find conditions similar to their own, and where they may examine certain pavements in actual use. The Contents are: Preparation of Streets for Pavements; Ancient Pavements; Modern Pavements; Concrete Base for Pavement; Block-Stone Pavements; Wood Pavements; Vitrified Brick Pavements; American Sheet-Asphalt, Artificial and Natural; Bituminous Macadam Pavement; Broken Stone Roads. There is an index of nine pages.

TABLES FOR OBTAINING HORIZONTAL DISTANCES

And Difference of Level from Stadia Readings. Computed by Alfred Noble and Wm. T. Casgrain. Cloth, 7 x 5 ins., 7 pp., 19 tables. New York, The Engineering News Publishing Co., 1902. $1.00.

The introduction describes the stadia rod, and the method to be used in graduating it, and gives the formulas for horizontal distances and differences of level from which the tables in the book have been calculated. The values for angles of elevation or depression up to 20° are given, and may be taken from the tables in a manner similar to that used in taking latitudes and departures from a traverse table.

TOPOGRAPHICAL RECORD AND SKETCH BOOK.

For Use with Transit and Stadia. By Daniel Lawrence Turner, Assoc. M. Am. Soc. C. E. Cloth, 7½ x 5 ins. New York, The Engineering News Publishing Company, 1902. 75 cents.

The introduction states that this record and sketch book is the outcome of efforts in teaching students topographical surveying. A sketch book with concentric circles and radial rulings was first tried by the author in 1896. The results proved to be so satisfactory that in 1898 a book containing such rulings was printed for students in the author's classes, where it has since been used with gratifying results. Believing that such a book may also be appreciated by fellow teachers and by engineers and surveyors generally, it is now placed at their disposal. The method of using the book is almost self-evident. The vertical rulings are of such form that they may be readily adapted to almost any method of recording. They are suitable for level notes, and also for the ordinary land survey and traverse records. The right-hand page can be used for any kind of sketching. As soon as the recorder has noted down the observed azimuth, distance, and vertical angle on the left-hand page, he proceeds to plot the corresponding point approximately in its true position on the sketch page, each point being designated by its number. As fast as the controlling points are plotted the sketch is drawn in. It is not necessary to reduce the elevations in the field, the sketch as drawn need only indicate the configuration. The book contains 75 pages ruled for notes and sketching, and there is a table for the reduction of stadia notes.

STAND-PIPE ACCIDENTS AND FAILURES IN THE UNITED STATES.

A Chronological Record of Accidents to and Failures of Water-Works Stand-Pipes in the United States, with Full Discussion and Assignment of Theories. Also a discussion of Current Practice in Specifications for Stand-Pipes and of other Related Matters. By Wm. D. Pence. Paper, 7 x 4 ins., 7 + 195 pp., illus. New York, Engineering News Publishing Co., 1895. $1.00.

The author states in the preface that, as originally contemplated, the record was to consist simply of a compilation of facts and data relating to the various cases described, but it early became evident that the investigation would lack a very important feature should no attempt be made to digest the compiled facts for the purpose of formulating a definite theory for each accident or failure included in the record. Therefore, an effort has been made to meet this requirement by giving close consideration to all

available information bearing upon the conditions and circumstances attending or leading up to the several accidents. A list of references to sources of information is given at the conclusion of each description. With the exception of a few additions and revisions, the original record comprising the body of the book is a reprint of a series of articles which appeared first in *Engineering News* during the months of April, May and June, 1894.

Gifts have also been received from the following:

Am. Ceramic Soc. 1 vol.
Am. Electrochemical Soc. 1 bound vol., 1 pam.
Am. Inst. of Min. Engrs. 1 bound vol.
Ark.—R. R. Comm. 1 bound vol.
Assoc. des Ingén. Sortis des Ecoles Spéciales de Gand. 1 pam.
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Norfolk & Southern R. R. Co. 1 pam.
North, Edward P. 1 vol., 4 pam., 1 map.
North-East Coast Inst. of Engrs. and Shipbuilders. 1 bound vol.
Northern Pacific Ry. Co. 2 pam.
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Pacific Coast Co. 1 pam.
Purdon, C. D. 1 pam.
Reading, Pa.—Water Dept. 7 bound vol., 1 pam.
Rome, R. Università Romana, Scuola d' Applicazione per gl' Ingegneri. 1 pam.
Safford, Arthur Truman. 1 bound vol.
Schneider, C. C. 15 blue-prints.
Smith, T. Guilford. 1 vol.
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Univ. of Tex. Mineral Surv. 1 pam.
Univ. of Wis. 2 vol.
Webster, George S. 1 bound vol., 1 vol.
Western Ry. of Alabama. 1 pam.
Wilgus, W. J. 1 bound vol.
Winchester, Mass.—Water Board. 13 pam.
Woonsocket, R. I.—Board of Water Commrs. 1 pam.

BY PURCHASE.

Die Elektricitäts Generatoren auf der Pariser Weltausstellung in 1900. Von C. F. Guilbert. Paris, C. Naud, 1902.

Die Funkentelegraphie. Gemeinverständliche Vorträge von A. Slaby. Zweite Auflage. Berlin, Leonhard Simion, 1901.

The Electric Arc. By Hertha Ayrton, M. Inst. E. E. New York, The D. Van Nostrand Company; London, "The Electrician" Printing and Publishing Company, Limited, 1902.

Die Eis- und Kälteerzeugungs-Maschinen. Ihr Bau und ihre Verwendung in der Praxis. Ein Compendium der gesamten Kälte-Industrie. Von Richard Stetefeld. Stuttgart, Max Waag, 1901.

Practical Metallurgy and Assaying; a Text-Book for the Use of Teachers, Students and Assayers. By Arthur Hiorns. London, Macmillan and Co., Limited; New York, The Macmillan Company, 1902.

The Mineral Industry, Its Statistics, Technology, and Trade in the United States and Other Countries to the End of 1901. Founded by the Late Richard P. Rothwell. Edited by Joseph Struthers. Vol X. New York and London, The Engineering and Mining Journal, 1902.

The Prospector's Handbook. A Guide for the Prospector and Traveller in Search of Metal-Bearing or Other Valuable Minerals. By J. W. Anderson, F. R. G. S., F. I. Inst. Ninth Edition. London, Crosby Lockwood and Son; D. Van Nostrand Company, New York, 1902.

The Arithmetic of Electrical Measurements, with Numerous Exam-ples, Fully Worked. By W. R. P. Hobbs, Assoc. Inst. E. E. Revised to Date by Dr. Richard Wormell. Tenth Edition. London, Thomas Murby; New York, D. Van Nostrand Company, 1902.

Report of the Tests of Metals and Other Materials for Industrial Purposes Made with the United States Testing Machine at Watertown Arsenal, Massachusetts, during the Fiscal Year Ended June 30, 1899. Washington, Government Printing Office, 1900.

Water and Its Purification; a Handbook for the Use of Local Authorities, Sanitary Officers, and Others Interested in Water Supply. By Samuel Rideal. Second Edition, Revised and Extended. London, Crosby Lockwood and Son; Philadelphia, J. B. Lippincott Company, 1902.

The Sea-Coast. By W. H. Wheeler, M. Inst. C. E. Longmans, Green and Co., London, New York and Bombay, 1902.

SUMMARY OF ACCESSIONS.

From October 8th to November 11th, 1902.

Donations (including 22 duplicates)	361
By Purchase	11
Total	372

MEMBERSHIP.

ADDITIONS.

MEMBERS.

		Date of Membership.
BELL, GEORGE JOSEPH		
County Surv. and Bridge Master for Cumberland, 16 Portland Sq., Carlisle, England...	Assoc. M.	Nov. 1, 1898
	M.	Oct. 1, 1902
HOLBROOK, ELLIOT		
Chf. Engr., K. C. S. Ry., Thayer Bldg., Kansas City, Mo		Sept. 3, 1902
KENDRICK, JULIAN WAY		
City Engr., Birmingham, Ala		Oct. 1, 1902
MATHER, THOMAS HOGGAN		
Chf. Engr., Syracuse R. R. Constr. Co., 45 Nottingham Bldg., Syracuse, N. Y		Oct. 1, 1902
SANBORN, FRANK BERRY		
Prof. of Civ. Eng., Tufts College, Mass		Oct. 1, 1902
SCHALL, FREDERICK EDWARD		
Bridge Engr., Lehigh Valley R. R., South Bethlehem, Pa.		Oct. 1, 1902
SUBLETTE, GEORGE WASHINGTON		
City Engr., Minneapolis, Minn		Oct. 1, 1902
THOMPSON, FRED		
Civ. Engr., U. S. N., Navy Yard, Norfolk, Va		Oct. 1, 1902

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Care, Milliken Bros., 11 Broadway, New York City		Nov. 5, 1902
DAVIS, LEONARD HENRY		
Chf. Asst. Engr., The Lake Superior Power Co., Sault Ste. Marie, Ont., Canada		Nov. 5, 1902
FENKELL, GEORGE HARRISON		
Civ. Engr. to Commrs. of Water-Works, Water Office, Erie, Pa	Jun.	Jan. 3, 1899
	Assoc. M.	Oct. 1, 1902
GIDEON, ABRAHAM		
27 Schnirel Bldg., Geneva, N. Y		Sept. 3, 1902
HALL, LOUIS WELLS		
305 Slocum Ave., Syracuse, N. Y		Oct. 1, 1902
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Engr., N. Y. Expanded Metal Co., 256 Broadway, New York City		Nov. 5, 1902
HATT, WILLIAM KENDRICK		
Prof. of Applied Mechanics, Purdue Univ., Lafayette, Ind		June 4, 1902
HENDERSON, JOHN THOMAS		
Asst. Engr., Conn. River Bridge and Highway Comm., P. O. Box 702, Hartford, Conn		Sept. 3, 1902

Date of Membership.

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Supt. of Water-Works and Sewers, Concord, Mass....... Nov. 5, 1902

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Civ. and Hydr. Engr., Niagara Falls, Ont., Canada...... June 4, 1902

OLBERG, CHARLES REAL
Asst. Engr., Tonopah Water & Power Co., Tonopah, Nev. May 7, 1902

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Room 500, Grand Central Station, New York City.................................. Jun. Apr. 3, 1900; Assoc. M. Oct. 1, 1902

WALKER, JOSEPH JEANES
Care, American Bridge Co., 7 West 22d St., New York City. Nov. 5, 1902

JUNIORS.

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1st Lieut., Corps of Engrs., U. S. A., Washington Barracks, Washington, D. C............................ Oct. 7, 1902

BAKER, HAROLD JAMES MANNING
408 Jefferson St., Port Townsend, Wash................. Oct. 7, 1902

BOARDMAN, HOWARD EDWARD
227 West 33d St., New York City....................... Oct. 7, 1902

BURROWES, HARRY GILBERT
Res. Engr., Div. No. 3, Atlantic Ave. Impvt., L. I. R. R., 5 Hanson Pl., Brooklyn, N. Y....................... Sept. 2, 1902

DAVIS, GEORGE JACOB, Jr.
Instructor in Civ. Eng., Univ. of Wisconsin (Res., 1104 West Johnson St.), Madison, Wis.................... Nov. 4, 1902

EDWARDS, OLIVER CROMWELL, Jr.
508 North 5th St., Steubenville, Ohio.................. Oct. 7, 1902

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10 East 4th Ave., Spokane, Wash....................... Oct. 7, 1902

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Glenville, W. Va...................................... Oct. 7, 1902

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P. O. Box 72, Harrisburg, Pa. .... Oct. 7, 1902

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46 Clark St., Auburn, N. Y............................ Oct. 7, 1902

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Silver Creek, N. Y..................................... June 3, 1902

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	Date of Membership.
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WILLIAMS, ROGER BUTLER, Jr .... 315 South Albany St., Ithaca, N. Y.

DEATHS.

Davis, John Woodbridge..............Elected Member June 3d, 1885; died November 7th, 1902.

Latrobe, Charles Hazlehurst.........Elected Member November 16th, 1870; died September 19th, 1902.

Mendell, George Henry..............Elected Member September 6th, 1876; died October 19th, 1902.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST.

(October 8th to November 11th, 1902.)

NOTE.—*This list is published for the purpose of placing before the members of the Society the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS.

In the subjoined list of articles references are given by the number prefixed to each journal in this list.

(1) *Journal*, Assoc. Eng. Soc., 257 South Fourth St., Philadelphia, Pa., 30c.
(2) *Proceedings*, Eng. Club of Phila., 1122 Girard St., Philadelphia, Pa.
(3) *Journal*, Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal*, Western Soc. of Engrs., Monadnock Block, Chicago, Ill.
(5) *Transactions*, Can. Soc. C. E., Montreal, Que., Canada.
(6) *School of Mines Quarterly*, Columbia Univ., New York City, 50c.
(7) *Technology Quarterly*, Mass. Inst. Tech., Boston, Mass., 75c.
(8) *Stevens Institute Indicator*, Stevens Inst., Hoboken, N. J., 50c.
(9) *Engineering Magazine*, New York City, 25c.
(10) *Cassier's Magazine*, New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 25c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News*, New York City, 15c.
(14) *The Engineering Record*, New York City, 12c.
(15) *Railroad Gazette*, New York City, 10c.
(16) *Engineering and Mining Journal*, New York City, 15c.
(17) *Street Railway Journal*, New York City, 35c.
(18) *Railway and Engineering Review*, Chicago, Ill., 10c.
(19) *Scientific American Supplement*, New York City, 10c.
(20) *Iron Age*, New York City, 10c.
(21) *Railway Engineer*, London, England, 25c.
(22) *Iron and Coal Trades Review*, London, England, 25c.
(23) *Bulletin*, American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gas Light Journal*, New York City, 10c.
(25) *American Engineer*, New York City, 20c.
(26) *Electrical Review*, London, England.
(27) *Electrical World and Engineer*, New York City, 10c.
(28) *Journal*, New England Water-Works Assoc., Boston, $1.
(29) *Journal*, Society of Arts, London, England, 15c.
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* Illustrated.

Vol. XXVIII. NOVEMBER, 1902. No. 9.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

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Vol. XXVIII. NOVEMBER, 1902. No. 9.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

VIRTUAL GRADES FOR FREIGHT TRAINS.

By A. C. Dennis, M. Am. Soc. C. E.

To be Presented December 3d, 1902.

It is well known to railway operating men that a run at a hill, especially a short one, is a great help toward getting the train over it. The tonnage rating for heavy freights, over probably every road in America, is greater than the load that can be started at certain points. The engineering departments of our railways know, in a general way, that momentum is of some help, but few have attempted to take advantage of it when fixing grades, or have investigated to what limits it could be used.

During the past year more than 3 000 miles were run by the writer with a dynamometer, on heavy freight trains loaded much beyond the rating for the ruling grade, to see what minor grades could be run with momentum, and where the stalling point was on those which could not be run.

The dynamometer record was condensed and plotted on profile paper above the grade and alignment; speed, pull, grade, and curvature being thus shown, so that train resistance could be readily taken from the pull of the locomotive and compensated for change of speed or velocity head, grade and curvature.

Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

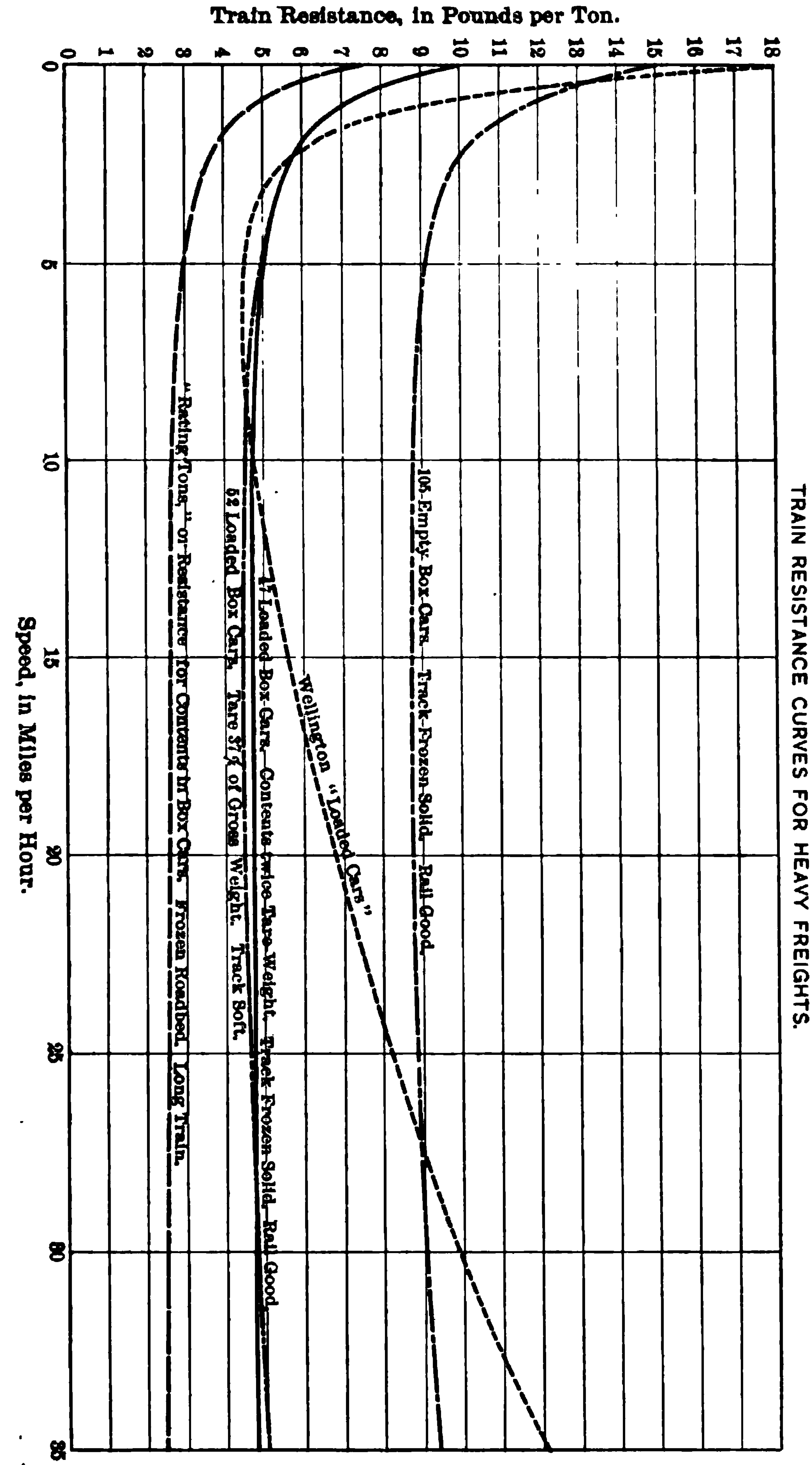
TRAIN RESISTANCE CURVES FOR HEAVY FREIGHTS.
Train Resistance, in Pounds per Ton.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
105-Empty Box Cars.—Track-Frozen-Solid.—Rail Good.
47 Loaded Box Cars.—Contents twice Tare Weight. Track Frozen Solid—Rail Good.
52 Loaded Box Cars. Tare 3/7 of Gross Weight. Track Soft.
Wellington "Loaded Cars"
"Rating Tons," or Resistance for Contents in Box Cars. Frozen Roadbed. Long Train.
0 5 10 15 20 25 30 35
Speed, in Miles per Hour.

FIG. 1.

The train resistance, in pounds per ton, compensated for change in velocity head, grade and curvature, was plotted for very many points and speeds for each train, and the mean of these points taken, as nearly as possible, for each train.

Fig. 1 shows what is believed to be the correct resistance under the conditions shown, and differs radically from the results obtained by Wellington and other authorities experimenting with light trains, cars and rails.

The experiments indicate that the resistances which increase with speed balance very nearly the decreasing journal friction for trains of box cars of 2 000 tons or more, the tare of which is one-third of the gross weight on a solid frozen roadbed. The resistance for such a train is about 4.7 lbs. per ton for speeds from 7 to 35 miles per hour. Warm weather and a less rigid roadbed modify this, somewhat, reducing the resistances at low speed and increasing them at high speed, but the difference is so slight that the 4.7 lbs. has been used as a constant. The resistance due to cold varies from enough to skid the wheels, it is said, to practically nothing after the train has been run fast for some time.

The resistances after the train has stood for some time are about 2 lbs. per ton above the normal until the train has been run enough to get the journals well lubricated and warmed.

The resistances seem to be greater than normal when increasing the speed and less when decreasing, after compensating fully for the change of velocity head. A train increasing its speed from 10 to 20 miles per hour, and maintaining it, would pull appreciably harder than if just reduced to 20 miles an hour from a higher speed. From coasting tests, with the locomotive shut off, it appears that the resistances per ton for the locomotive were about the same as for empty cars, or about 9.0 lbs. per ton.

As train resistances vary with the loading, it was necessary to adopt a common basis, or "Rating Ton," as the unit for comparing trains. The unit adopted, called the rating ton, is the ton of loading in a box car, or the tare weight reduced to its equivalent in resistance to a ton of load.

The train resistance for a rating ton, for speeds from 7 to 35 miles, is practically constant at 2.6 lbs. per ton. To reduce tare to rating tons for 0.4% ruling grade, for example, the following method is

Tractive Power, in Pounds

0 10 000 20 000 30 000

LOCOMOTIVE TRACTIVE POWER CURVE

Speed, in Miles per Hour.

FIG. 2.

used: The train resistance for the rating ton is 2.6 lbs., and the gravity 8.0 lbs.; or, 10.6 lbs. per ton, total resistance. A ton of tare has 9.0 lbs. train and 8.0 lbs. gravity resistance, or 17.0 lbs. total, which is 160% of the rating ton. Similarly, to change tare into rating tons, multiply by 160%, 151%, 144%, 139%, 134%, 131% and 128%, respectively, for the rating-ton equivalent on 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0% grades.

Fig. 2 shows the tractive power at the drivers, for a consolidation locomotive, as actually performed. The locomotive was a Pittsburg Compound. The weights are as follows:

Pony truck		16 625 lbs.
Drivers	32 875 lbs.	
	32 125 "	
	36 175 "	
	32 225 "	
On drivers		133 400 "
Locomotive		150 025 "
Tender		109 025 "
Grate area		32.25 sq. ft.
Heating surface of tubes		1 717 "
" " " fire-box		155 "

The working pressure is 200 lbs., which is sufficient to slip the drivers on good rail, up to 8 miles per hour, or higher. The boiler capacity was sufficient to keep a steam supply for all ordinary work. The curve of tractive power was obtained by adding to the dynamometer pull at any point the grade and rolling resistance of the locomotive and tender. The points of trial selected were those where the locomotive should have been working near the maximum, and covered a large range of speeds and many repetitions at the same speed. These results have been plotted, and the curve shown is what is thought to be a fair average. In general, this curve lies about 1 000 lbs. below the irregular maximum.

After the locomotive has been worked to the maximum for about a mile there is a considerable drop in power, due to failing steam pressure, so that the velocity grade curve of the next tenth higher grade (Figs. 3, 4 and 5) will give results more nearly corresponding to the actual performance of the locomotive after passing the first mile

0.4%

DIAGRAM SHOWING DISTANCES FOR VARIOUS CHANGES IN VELOCITY ON GRADES SHOWN, FOR CONSOLIDATION LOCOMOTIVE WORKING COMPOUND AND HAULING FULL RATING FOR 0.4% GRADE, COMPENSATED.

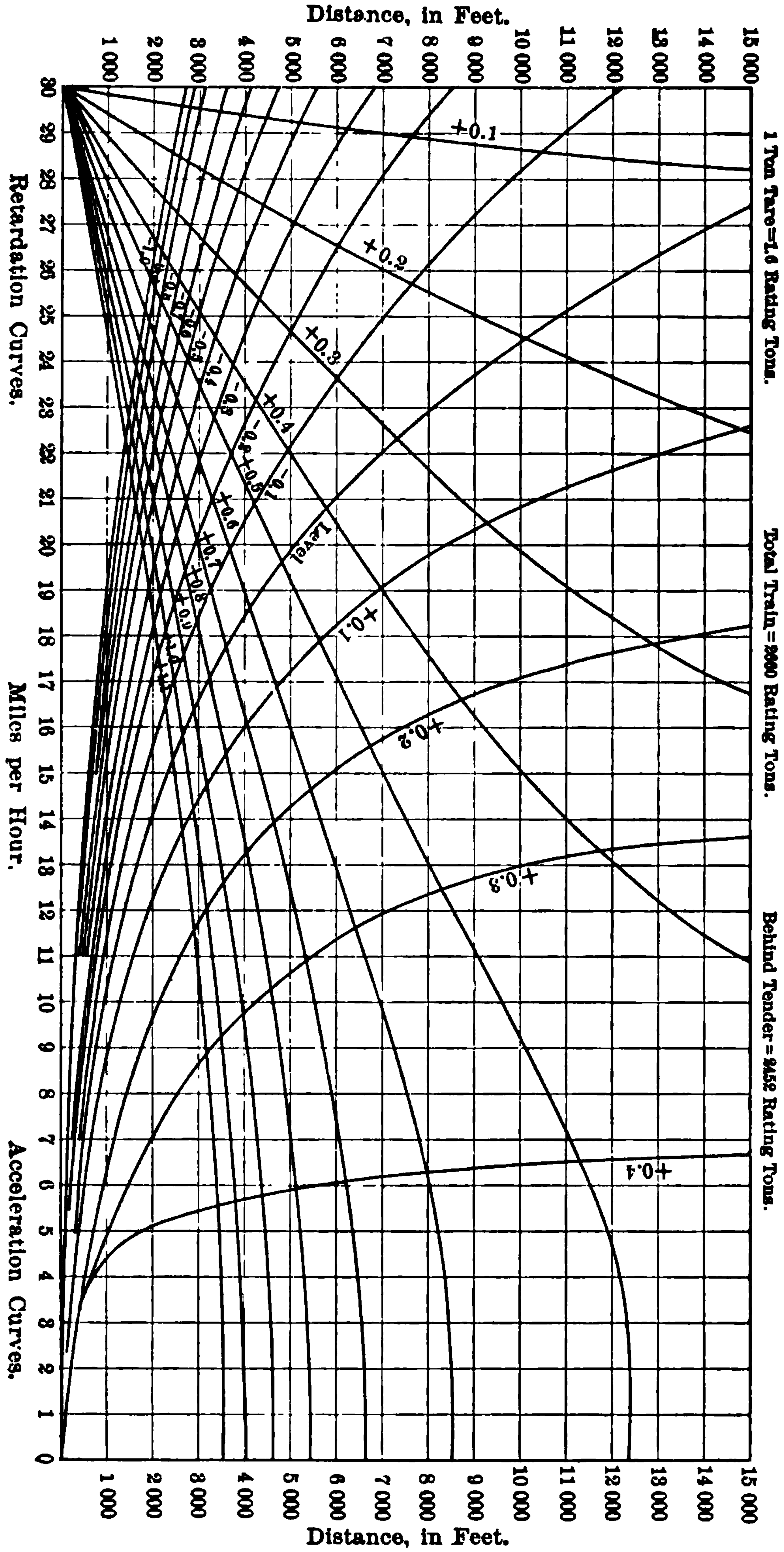

Fig. 8.

when working on a grade in excess of that for which the locomotive is loaded.

The rating for this locomotive, in rating tons at 7 miles per hour on a 0.4% grade, is equal to the tractive power at the drivers for that speed (28 200 lbs.), divided by the resistance per ton (8.0 lbs. gravity + 2.6 lbs. train) $= \frac{28\ 200}{10.6} = 2\ 660$ gross tons for the total train. The gross train less the locomotive and tender (130 tons actual $\times$ 1.60% = 208 rating tons) = 2 660 — 208 = 2 452 rating tons behind the tender. For a train loaded with two contents to one tare, for every 3 tons there are 2 tons contents, which equals 2 rating tons, and 1 ton of tare equals 1.60 rating tons; the equivalent load, then, for the 2 452 rating tons is $\frac{3}{2 + 1.60} \times 2\ 452 = 2\ 046$ actual tons behind the tender loaded two contents to one tare. The rating for all tare $= \frac{2\ 452}{1.60} = 1\ 529$ tons. The rating for 25 miles per hour on a 0.4% grade $= \frac{12\ 750}{10.6} = 1\ 203$ gross rating tons; and 1 203 gross, less 208 locomotive and tender, = 955 rating tons behind the tender = 803 tons of train loaded with two contents to one tare, or 597 tons all tare.

The tractive power divided by the gross "Rating Tonnage" gives the pounds per ton of power. From this take the train and gravity resistance, in pounds per ton, and the remainder will be the force for acceleration if plus, and for retardation if minus. This remainder, reduced to its grade equivalent, at 2 lbs., = 0.1% grade, and divided into the difference in velocity heads for two speeds, will give the distance necessary for that change of speed. The speeds for each change of one mile per hour should be taken separately and the sum taken, if it is desired to calculate the distance accurately.

A table was calculated and curves plotted from it showing the performance of the locomotive on various grades and at various speeds on the basis of the above-determined train resistances and engine power: Figs. 3, 4 and 5 for 0.4%, 0.5% and 0.6% grades, respectively.

The distance ordinate for any particular grade rate shows the distance necessary to run from 0 or 30 miles per hour, as the case may be, in order to attain the corresponding speed; and, inversely, the speed attained or lost between two distant ordinates. As an example: On the 0.4% diagram, suppose a start to be made on a level grade 5 000 ft. long, followed by 4 000 ft. of 0.6% grade, fol-

0.5%

DIAGRAM SHOWING DISTANCES FOR VARIOUS CHANGES IN VELOCITY ON GRADES SHOWN, FOR CONSOLIDATION LOCOMOTIVE WORKING COMPOUND AND HAULING FULL RATING FOR 0.5% GRADE, COMPENSATED.

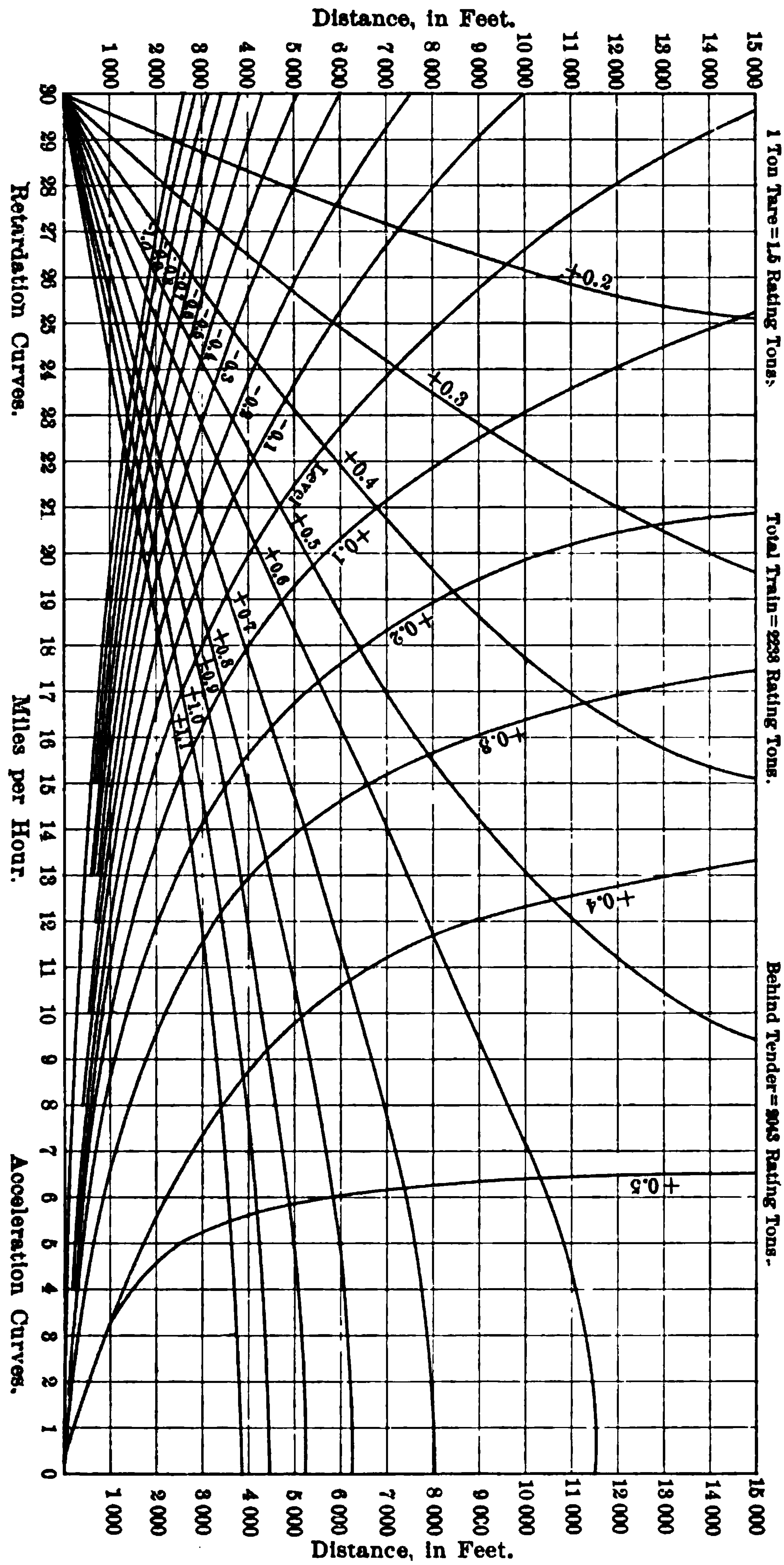

Fig. 4.

lowed by 3 000 ft. of — 0.2% grade. The speed ordinate corresponding to 5 000 ft. on a level grade is 20 miles per hour; 20 miles per hour on a 0.6% grade corresponds to a distance of 3 600 ft., being the distance required for speed reduction from 30 to 20 miles per hour; 4 000 ft. more distance on the 0.6% grade, or 7 600 ft., corresponds to 9½ miles per hour, the speed at the top of the 0.6% grade; 9½ miles per hour on the — 0.2% grade corresponds to a distance of 500 ft.; 3 000 ft. more distance on the — 0.2% grade, or 3 500 ft., corresponds to 21½ miles per hour, the speed at the foot of this — 0.2% grade.

Some experiments were made with a ten-wheel locomotive of large boiler power and big drivers, with the hope that this type would be better suited to operate momentum grades because of its higher efficiency at high speeds, but the results were rather disappointing, as stops have to be figured on at each station. The ten-wheel locomotive holds speed better, but attains it less readily, and, in general, when running for an adverse grade from rest, reaches the foot of the grade at less speed than the Consolidation, but holds it better, stalling at about the same place.

The railway engineer's almost universal disapproval of momentum grades is probably caused by the lack of an easily-worked method of defining the limits for their proper use, and the mistaken idea that their introduction will cause stalling from bad weather conditions or from the power being in bad condition. These adverse conditions apply with greater force to long ruling grades than to the shorter steeper momentum grades, as adhesion and steaming power are taxed more, or taxed longer, on the former grade, if the momentum grades are not the ruling grades under favorable conditions. In momentum grades part of the work is done by momentum, which is not affected by weather conditions.

Whether or not the engineers who locate railways figure on momentum, the operating officials take advantage of it to pull what they are able, regardless of the rate of grade. One division which the writer studied had 0.5% east-bound and 1.0% west-bound grades—these grades being very fairly arranged to balance the heavier east-bound traffic—but because of the length of grade with stops, and uncompensated curvature on the 0.5% profile grade east-bound, the highest possible rating was that for 0.77%, while, by means of momentum, the shorter 1.0% grade west-bound could be operated with exactly the same rating as the east-bound.

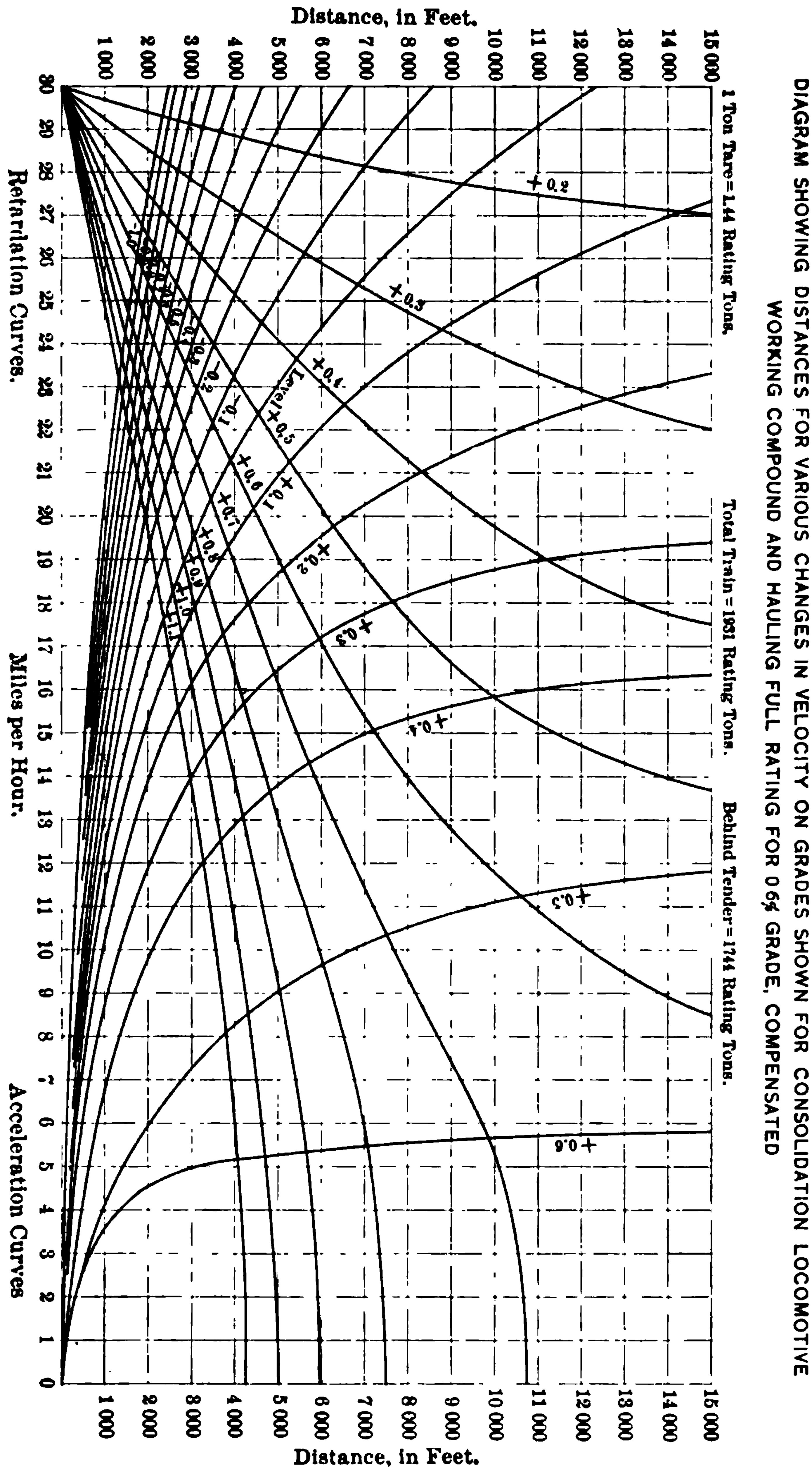
0.6%
DIAGRAM SHOWING DISTANCES FOR VARIOUS CHANGES IN VELOCITY ON GRADES SHOWN FOR CONSOLIDATION LOCOMOTIVE
WORKING COMPOUND AND HAULING FULL RATING FOR 0.6% GRADE, COMPENSATED
1 Ton Tare=1.44 Rating Tons.
Total Train=1931 Rating Tons.
Behind Tender=1744 Rating Tons.
Distance, in Feet.
Retardation Curves.
Miles per Hour.
Acceleration Curves

Fig. 5.

Grades out of a divisional point should be reduced to a somewhat lower grade than at other points, as the first few miles a train is run after standing for some time show a very much higher resistance than the normal, especially in cold weather. The writer knows of one case, in extremely cold weather and high wind, but with pretty clean rails, when it was impossible to start a train out of a level, crooked yard with the locomotive unassisted, but the same locomotive, an hour afterward, handled this train on a 0.4% grade as usual.

For ordinary stops, at least 0.1% compensation is advisable, although a compound locomotive can generally start anywhere that it can be run through without losing speed, but at greater risk of broken draft rigging and loss of time, to avoid which generally justifies a slacking of the ruling grade.

On favorable divisions, the rating can be raised 50% for about 10% of the original construction cost by the proper introduction of momentum grades, and, incidentally, the rise and fall and curvature be improved. These improvements may often postpone indefinitely the necessity for double track, and are in line with, as well as being a preliminary to, double-tracking. Because of fewer stops, momentum grades generally tax locomotive powers less on double-track lines.

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IMPROVEMENT OF THE BLACK WARRIOR, WARRIOR AND TOMBIGBEE RIVERS, IN ALABAMA.

Discussion.*

By Messrs. William M. Hall, B. F. Thomas, D. M. Andrews and R. C. McCalla.

William M. Hall, M. Am. Soc. C. E. (by letter)—The writer has read this paper with much interest, and, as the literature on the locating of locks and dams is very scant, it is hoped that the Society will soon have more papers on the same subject. Mr. Hall.

The writer will not discuss the paper; but, as he has assisted in the location of several locks and dams; and, as he has been engaged during the past year on the location of two Ohio River locks and movable dams, some of the guides which he is using in the latter work may be of interest to others. They are briefly as follows:

1. Select a location where sufficient width can be had for a lock 110 ft. wide, a navigation pass of 600 ft., and a weir of at least 250 ft.

2. Select a location which, with small expense, will admit of the passage of tows around the coffer-dams of the various parts during construction.

3. Select a location where the sill of the navigation pass can be placed above the bed of the river, and, as low as the controlling contour above and below, without danger of the movable parts, when down, becoming buried in sand.

* Continued from October, 1902, *Proceedings*. See April, 1902, *Proceedings*, for paper on this subject by R. C. McCalla, M. Am. Soc. C. E.

Mr. Hall. 4. Prefer a location where the channel above and below will be straight for 2 000 ft. or more; and avoid locations where it will be necessary to "flank" fleets of barges in passing through the navigation pass.

5. By use of core-drills for testing the depth to and quality of ledge rock, and by other careful investigation, select the location, filling the above conditions, which has the best natural foundation within the limits of the stretch of river on which it is possible to place the lock and dam.

6. Prefer a location at the foot of a shoal with a natural pool below and near by.

7. Prefer a location below and near navigable tributaries; thereby improving the tributaries as well as the main stream.

8. Seek locations with good, firm and high banks, and with suitable land near by for power-house, store-house and the tenders' quarters.

9. Prefer a location where the lock can be placed on the opposite shore from drift. (On the upper Ohio, the prevailing winds being from the west, unless the conformation of the river or local tributaries prevent, the wind usually carries the drift near the easterly shore.)

10. If necessary to select a location in a bend, prefer to place the lock next the concave shore, and as near to the head of the bend as other conditions will allow.

11. Avoid cutting the harbors of important towns or cities in twain by a lock and dam.

The writer wishes to acknowledge the receipt of much information on the foregoing subjects from the reading of Department Reports by W. H. Bixby, Major, U. S. A., M. Am. Soc. C. E., and B. F. Thomas, M. Am. Soc. C. E., and by the discussion of these subjects with them and with W. E. Craighill, Captain, U. S. A.

Mr. Thomas. B. F. Thomas, M. Am. Soc. C. E. (by letter).—All engineers engaged in designing and constructing works of river improvement have felt the need of papers of this character, giving in detail the various parts of the design and methods of construction. Except in a general way, and in isolated pamphlets, there is no work, except De Lagrene's "Cours de Navigation Intérieure," which treats of this important branch of engineering, and this treatise, published some thirty years ago, is now out of print. Then there are numerous Government reports which contain valuable information, but a search for it involves an expenditure of much time and labor; so much, in fact, that a busy engineer cannot undertake the task. This paper, coming at a time when many engineers are engaged in the study of projects for improving rivers by canalization, is a valuable addition to literature of this class; and, owing to the care with which it has been prepared, it will

prove of much benefit to such engineers, and of interest to those not thus engaged. Mr. Thomas.

It is not the purpose of the writer to review the paper in detail, but rather to discuss the subject generally from the standpoint of one who has been giving it pretty close attention for a number of years.

Location.—The practice of making trial borings for foundations is a most excellent one, and no work of importance should ever be commenced without first making a careful examination of the river-bed material. This has been too often neglected, sometimes with disastrous results. Not only is this necessary in order to determine the character of the structure to be built, but it is also advisable from the standpoint of economy. Investigation, with proper appliances, of all the possible sites is the only method by which the cheapest as well as the most suitable location can be chosen. The borings, where rock exists, should extend into the ledge from 4 to 5 ft., in order to be fairly certain that a boulder or loose rock has not been encountered, and they should be made at intervals of not more than 50 ft. under the important parts of the structures. The water-jet method used by the author is very satisfactory, but, where the number of holes is limited, or where there is an insufficient depth of water to float a suitable plant of this character, the writer has found the method of driving the casing with hand pile-drivers quite economical, and sufficiently rapid for ordinary purposes. A light pile-driver, which can be carried anywhere by three or four men, is set up on the sand bars, or on a light-draft pushboat, and fitted with a banded wooden hammer of such weight as can be lifted readily. This is operated by four men pulling on a rope attached to it and passing over a sheave in the head of the driver. Two of the men stand on the second floor of the driver and two on the bottom. As the pipe is driven the material is pumped out with a sand pump, the driving being stopped during the operation. When bed-rock is reached, a churn drill is dropped into the casing, and the hole is continued with it.

In seeking his locations in "curved instead of straight reaches" the author has departed from the usual practice, but, when the curve is of very long radius, the idea is to be commended; because in, such locations, with the lock on the convex shore, protection from drift is afforded, which cannot always be counted on in straight reaches. It is not good practice, however, to place a lock having a fixed dam in an abrupt bend, but when the conditions require it (as they sometimes do, because it seems that the best foundations are usually on the concave sides of bends), the question at once arises as to whether to place the lock on the convex shore (the "point"), as the author has done, or on the concave bank (the "sag or bend"), as has been the most general custom. In a river carrying considerable drift, the "point" side is indicated because of the protection it affords, but such location renders

Mr. Thomas. a lock more difficult and dangerous of entrance from above, because of the necessity of "hugging the point" in order to keep the stern of the boat from being caught, by the stronger current away from the shore, and rounded to. Should the machinery become disabled, or high winds prevail at such a time, disaster is likely to follow, because of the proximity to the dam; and it is never wholly safe to enter from above without running out a shore line. Another argument against such a location is the fact that the quiet water or eddy immediately "under a point" causes deposit, and shallow water results, making the entrance difficult, and often requiring dredging. The danger to craft can be partially overcome by the prolongation of the land wall up stream by a retaining wall for a distance equal to the length of craft to be locked, so that boats may come alongside of it before getting too close to the dam.

Where the location is on the concave bank there is usually no difficulty of approach and entrance from above, but drift goes into the head-bay incessantly and causes more or less trouble. Owing to the current setting against the bank below, some difficulty of exit will often occur. There is much less trouble from deposit in such a location than in a point location.

Fixed or Movable Dams.—Where adjacent lands are subject to overflow it is always well to guard against increasing the height of the flood level, and it is unnecessary to state that the erection of fixed barriers across a stream which raise its low-water level will also raise its high-water level. The author gives the present depth of overflow of the valley at from 5 to 10 ft. for several miles in width. It is quite probable that the flood line will go perceptibly higher upon the completion of the system of fixed dams.

In a country not troubled with ice it would seem that movable dams could be kept up at all times, except when the stage of water was ample without them, and thus give constant navigation, and if proper care is used in construction there will be no loss of water by leakage. The writer has not yet seen a fixed wooden dam that will compare in tightness with the needle dam at Louisa, Ky., which is in a river having a minimum discharge of less than one-third of that of the river under discussion. In the six years it has been in operation there has never been a time when the pool could not be kept at normal height. This condition, doubtless, will change to some extent, however, when others of the system have been completed, and lockages become more frequent. The author states that "the cost of construction, operation and maintenance is much greater with movable than with fixed dams." A glance at the reports of the cost of the operation and maintenance of the Kanawha Dams will disprove this supposition, and, as to first cost, it must be remembered that, while the foundations of movable dams are of masonry, those of fixed dams are usually of crib work—

a cheaper and less durable material. In fifty years the wooden dam will have been partially rebuilt twice, while the masonry will still be good. Given the same grade of material and workmanship, the movable dam has no disadvantage on the score of cost of construction or in operation and maintenance. The argument that wood will last forever under water does not prove true in stationary dams, where it not only decays, but frequently actually wears out clear down to the river bed. Mr. Thomas.

The fact that tows are small will hardly justify breaking them up to pass them through the locks, because small tows are moved at much greater expense (per ton) than large ones, and the delay will add to this expense. A model river, during good stages of water, should enable a tow to proceed without interruption when once under way; under no other condition can coal be moved at a minimum of cost. As to drift carried by floods increasing the cost of operation and maintenance, experience proves that but little drift travels until after the dams are lowered. Occasionally, however, dams near large tributaries have been injured by the appearance of drift before the lowering could be completed, and it is not always wise to build such dams in preference to fixed dams.

Probably the worst enemy to movable dams is ice. It appears at times when there is not sufficient water for navigation, and yet, in order to be sure that the dams will not be injured, they must be lowered. This may strand loaded barges or other craft, and entail tremendous loss, as well as stop navigation. A case in point is the dam at Davis Island on the Ohio, which forms a harbor for Pittsburg. Owing to the early freezing of the Allegheny, it is frequently necessary to lower this dam when there is very little water for open-river navigation, and the loss and inconvenience thus occasioned are wide spread, affecting many industries in this busy community. This seems to have been a case where a fixed dam would have been preferable, even though it made it necessary that all navigation should pass through the lock. Another solution, and possibly a more satisfactory one, would have been the construction of a bridge dam (which can be operated in the ice) at the site of the next dam below, which is fortunately in a narrow place in the river where there is an island. The cost of such a dam probably would not greatly exceed that of the two which it would replace, and there would be only one lock to pass through, instead of two as at present, a very great advantage on that river, where the tows are large and numerous.

Size and Depth of Lock.—One of the experiences quite common on improved streams is to find that insufficient depth has been provided, and that the locks are too small. Usually, the depth is regulated by the draft of the largest craft when loaded, with a slight allowance for clearance, but it seems that no sooner have good depths been pro-

Mr. Thomas. vided than better depths are demanded. Thus, on the Upper Ohio, a start was made a few years ago with 6 ft. on the sills, and 8 ft. is now asked for. Another example, still more striking, from the fact that the demands were granted, is the improvement of the Seine below Paris. The original slack-water system was established between 1838 and 1853, at a cost of $2 800 000, with a depth of 5½ ft. This depth was increased, between 1858 and 1878, to 6½ ft., at an additional cost of $2 800 000. Ten years later the depth was increased to 10½ ft., at a further cost of $12 200 000. The commerce, which amounted to very little under the first arrangement, owing to the inroads made upon it by the improvements in railroad traffic, has increased enormously with the greater depths for navigation. Similarly, may be cited, the St. Mary's Falls Canal improvements, completed in 1855, at a cost of $1 000 000. Between 1870 and 1881 the additional sum of $2 000 000 was expended for the purpose of accommodating the increasing commerce. In 1896 a lock, 800 ft. long and 100 ft. wide, giving a depth of 21 ft., was completed at a cost of $3 700 000. That further improvements will be required before many years, is quite apparent to those who are conversant with the commerce passing through the canal. It is evident, then, in studying the question of depths to be given on a river which is at all worthy of improvement, that it is far better to provide a much greater draft than indicated for present needs, in order to be reasonably certain that future commerce may be well served. The same idea should also be applied in fixing the size of a lock, because the trend of modern transportation is toward cheap rates, and these can be had only by using larger craft. It is much less expensive to build beyond present requirements in the start than it is to remodel later on to suit new conditions. The lift to be given a dam is determined by the rights of riparians, the proximity of water mills in tributaries, the heights of bridges crossing the stream, and by local conditions, such as suitable foundations, etc. Considering navigation interests solely, the greater the lift the better, because then the number of locks will be reduced, and boats will make better time and be subjected to fewer dangers. As a general thing, movable dams are much lower than they should be, and in many localities fixed dams are open to the same objection, but, as a rule, these have about all the height allowable, and in some places their effects on the unprotected banks below are very injurious. Unless the banks are of hard material they should be well protected below all fixed dams and particularly those of high lift. For movable dams, this protection can be much less, and is usually not necessary on the lock side, owing to the fact that the dams are lowered from the abutment end. In many instances the bank protection can take place gradually, as the original material is eroded.

Materials of Construction.—A good many of the older locks were built of wood; then came stone; and now it is concrete, which has not yet

been in use on this class of work long enough for engineers to be certain of its durability. No reason is apparent, however, why it should not be all that is desired, and it certainly simplifies construction very greatly, particularly in localities where good building stone is inaccessible. At first there was a disposition to use natural cements, but, as the Portlands became cheaper and better understood, they displaced the former, until now nearly all these structures are being built of American Portland cement. The prices have gone down, as the number of manufactories increased, until, within the past year, it has been possible to procure a first-class Portland cement in the Ohio Valley for less than $1.50 per barrel. The better grades of natural cement have proved quite satisfactory under water, but there are so many poor grades manufactured and sold that they have prejudiced the use of natural cement altogether. At first there was a disposition to criticise the appearance of concrete work, but, after several years' use, it is believed that this objection will not be apparent, as all walls become more or less marred by the rubbing of boats and barges. It is thought, also, that Portland cement will be too hard to show many scratches, and that, after ten years' service, the appearance of a lock face built of it will be superior to that of stone heretofore used. There is no doubt of its being a cheaper material in almost all localities where locks are to be built, and it eliminates entirely "stone cutters' strikes" and the use of skilled labor. Of late years this is a very considerable pecuniary advantage, because of the eight-hour law, which requires the United States to pay the same for eight hours' work as is paid for a full day's work by others in the locality. The rapidity with which a concrete wall can be put up is one of its chief advantages, as on many rivers the working season is very short, owing to high water; and it is impracticable to do very satisfactory stone work at night, as each stone must be brought from a pile at some distance and swung into place and lined up. With concrete the work can proceed without stopping, and one mixer will put out from 400 to 500 bbls. of cement in 24 hours, barring breakdowns and other delays. A single shift, working in daylight only, is placing an average of 200 cu. yds. of concrete daily, to the writer's knowledge. The proportions used are 1 part of cement, 3 of sand, and 6 of broken sandstone. At another lock the proportions are 1 bbl. of cement, 15 cu. ft. of sand, and $33\frac{1}{3}$ cu. ft. of broken limestone, varying in diameter from $\frac{1}{8}$ in. to $2\frac{1}{4}$ ins. This appears to be a little "lean," but the product seems to be hard and strong. Common river sand is used, about 70% of which will pass a No. 30 sieve, 50% a No. 50, and 2% a No. 100. Sandstone is somewhat soft, crushing slightly during the process of ramming, but limestone is very satisfactory. Experience proves that pieces which will barely pass through a $2\frac{1}{4}$-in. ring are too large, and that better results can be obtained by reducing this to $1\frac{1}{2}$ ins. and taking all the smaller particles down to $\frac{1}{8}$ in.—virtually, "run of crusher" stone.

Mr. Thomas. The larger stones seem to bunch together and cause voids, and will not pack like the smaller ones.

The author has adopted the block method of building; that is, each day's work forms a separate monolith. The method in most general use, probably, is that of the continuous monolith, in which the concrete is built from bottom to top without stopping. The block method is used on the Kentucky and Big Sandy Rivers, and is gradually growing in favor, although a stronger and more presentable wall can doubtless be made by the other method. In the continuous-monolith construction the form timbers are put up the entire height to begin with, and it is necessary to lift the concrete to the top and then lower it to position. This is frequently quite troublesome, the buckets knocking the forms out of line and threatening the safety of the men cooped up underneath. When the concrete is built in blocks it is only necessary to carry up the forms as the work progresses, and night work is not required at all. The design of forms varies in different localities, the most usual type being that with posts erected, inside of which lagging is placed as the work proceeds. The posts are braced at intervals, as may be necessary. Another style is that in which the lagging is tied together with rods, and held apart by braces, the rods being generally left in the completed work. There is some difficulty in holding forms of this class exactly in line, and their use is not general, although it effects quite a saving in cost. Dressed lumber should always be used for lagging, on all faces to be exposed after the completion; and a lining of sheet iron would prevent the graining of the wood from showing and would otherwise improve the appearance of the face of the wall. However, after a few years' use all chamber faces on rivers having a good commerce show more or less injury, and it is not essential that a beautiful wall be had at the start. The forms can be removed in from three to five days and used again. Upon their removal it is a good idea to go over the face of the wall and rub down rough places with a block of wood or soft stone. This will improve the appearance of the work greatly, and can be done very readily if attented to immediately after the lagging comes off.

Gates, Valves, etc.—The gates seem to be very well designed. Steel is now replacing wood for such structures, and will eventually do so entirely, unless experience proves its inadaptability for such work. It sometimes happens that boats strike the gates with considerable violence. In a wooden gate this does not result in permanent injury or in injury which cannot be repaired then and there. With a metal gate, the case is different. If it is struck with sufficient force to bend it, it may not spring back to place, in which case it will not miter, and becomes useless. To repair the damage it may be necessary to remove the gate and transport it to a shop—quite an undertaking. There are two general types of metal miter-gates now in use and under

construction on the rivers of this country: In one class the beams are placed horizontally, and transmit the strains to the walls and the opposite leaf through heel and toe posts; in the other class the supporting beams are placed vertically, connecting with horizontal girders at bottom and top. This class of gate has less metal than the other when the length is considerably greater than the height, but a heavy strain is transmitted through the top girder to the wall well toward its top. In the writer's opinion it is not to be preferred to the horizontal framed gate. A more serious objection to it is that when rust has weakened the uprights at the water line, as it probably will, the entire gate must be renewed. With horizontal framed gates it would only be necessary to renew the lower portion. The use of a buckle-plate skin will permit of a wider spacing of girders and effect a material saving of metal, because these plates are much stronger than flat plates of equal weight, and will require no stiffeners, even in very wide panels. Mr. Thomas.

Originally, metal gates had a double skin in order to secure buoyancy and consequent reduction of weight, but it was found that the compartments leaked and were not kept pumped out, so that the additional plating was simply so much weight to be carried without any beneficial result. It has also been found that the upper compartments fill with mud and induce rust. Without doubt the single-skin gate is to be preferred in every way. One objection to all metal gates is that they are likely to rust at the water line and below, when they cannot be kept clean and painted, and the writer has considered the advisability of building the upper portion of metal and the lower of wood. The latter could be renewed at any time without disturbing the former, and with very little delay to navigation. Wooden gates are short lived. The writer knows of few gates which have lasted more than sixteen years; many are partially renewed within ten years, and a few in less. There is only one lock provided with iron gates on the tributaries of the Upper Ohio, but these seem to be perfectly good after twenty-one years' service. In his work on mitering lock gates, Major Hodges gives the average life of a metal gate at forty years, when properly cared for and repaired.

The method of operating the gates adopted by the author seems to be undesirable, although experience may prove otherwise. Mechanism somewhat similar, but, doubtless, imperfect in construction, was tried a number of years ago on a lock on the Kentucky River, and, later, was supplanted by something else. The writer was told that it was not satisfactory, but has no information on the subject. The most common method of gate operation is by a rack-bar and pinion turned by capstan bars, but it is not wholly satisfactory, partially because of the friction of the rack and pinion and partially because the bar, in order to reduce its length, is attached to the gate too far from the toe. The prim-

Mr. Thomas. itive wooden spar and modern wire rope winding on a capstan, as seen on the Kanawha and elsewhere, is the simplest and most satisfactory device the writer has yet observed for hand operation. The spar and line are attached at the toe, the length of spar not being objectionable when it is an ordinary pole, and the best point from which to operate is thus secured. It is worthy of note that the new locks on the Moldau, in Bohemia, are provided with rack-bars operating under the coping, where they are out of the way during maneuvers. The same system has an example on the Fox River in this country.

The cost of wooden gates, for locks from 50 to 55 ft. wide, with about 12-ft. lift, ranges from $1 500 to $2 500 per leaf, usually being about $2 000. Steel gates will not usually cost any more, if designed with a view to economy. In adopting the balanced valve the author followed the practice which has the advantage of long and fairly satisfactory trial, and, with the modifications and arrangements which he has provided, most excellent results should follow. This valve is sometimes used with a vertical and sometimes with a horizontal axle, and seems to work equally well in either way. Other forms of valves in use are the gridiron sliding valve, in which the valve is pierced with rectangular openings, and the cylindrical valve, which consists of a cylinder, from 4 to 6 ft. in diameter and 18 to 20 ins. high, sliding vertically inside a chamber having a water-tight cover. This cylinder or ring encircles the culvert opening, and, when down, shuts off the water. When raised, which is an easy operation, as the water is pressing equally from all sides, the water goes into the culvert under the cylinder. This valve is in satisfactory use on the Muskingum River, and is being adopted for new locks on the Big Sandy and Kentucky. The writer has been considering the advisability of dispensing with the chamber over the cylinder, dropping its cover down to the top of the cylinder, and sliding the latter up on guides on the outside. This cylindrical valve has been rendered self-operating by the introduction of water through its cover, and a patent has been issued to Major W. L. Marshall, and another to Mr. Sanford L. Cluett, for devices of this character. Some of the latter have been made for trial on the Big Sandy, but are not yet in use.

General Remarks.—In preparing plans for work of the character of that under discussion it should always be remembered that repairs will be costly, tedious and detrimental to navigation, because the water will be troublesome, and it will be necessary to close the locks for a time. It is of the first importance, then, not only to make the various parts as simple as possible, but also to make them stronger than necessary. Especial attention should be given to designing all valves or other movable parts so that they can be readily removed for examination or repair. It is only necessary to go over one of the older improvements to be convinced of the necessity for such cautions. The

exposed ends of anchor bolts will rust eventually, so that renewal will be necessary, and it will be well to provide sleeve nuts in the original construction so as not to necessitate digging the old bolts out of the masonry. Mr. Thomas.

Of late years, considerable taste has been displayed in the design of lock buildings and in the care of the grounds. These places should be veritable parks, with grass, shade, flowers, and neat walks and fences; in fact, they should be object lessons to their several communities. A very little money will go a long way when all the labor is ready at hand and under pay the year round. The works themselves should be kept in the best of repair, and lock gates, irons, machinery, boats, and such property as can be improved thereby, should be thoroughly overhauled and painted every year. It is a lesson, to those engaged upon the works, which is very cheap at the price, as it causes each man to be more careful, to take more pride in his work and in himself, and thus he becomes a valuable citizen as well as a valuable employee.

D. M. ANDREWS, M. Am. Soc. C. E. (by letter).—This paper is a valuable contribution on a subject of which there is far too little information available. There is little to criticize in the paper; the writer, however, wishes to discuss certain of the points from the viewpoint of his own experience. Mr. Andrews.

The Black Warrior and Warrior are one and the same river; the name Black Warrior changing to Warrior at Tuscaloosa, as explained by the author. The Black Warrior has stable banks and bottom. The Warrior has caving banks and a shifting bottom.

The adoption of the fixed type of dam for the Black Warrior was unquestionably the best; and, for the reasons given by Mr. McCalla, particularly the small low-water discharge, the fixed type was the only type that could have been safely adopted for the Warrior. With the fixed type, however, the pools between the dams will in time fill up, and constant dredging will be required to maintain a channel of the proposed width and depth between the locks. With dams of the movable type this filling of the pools could be prevented by lowering the dams during periods of high water, and letting the river clear itself of accumulations of silt and gravel.

The writer believes that the advantages or disadvantages of locations at convex or concave shores are, except in abnormal situations, more apparent than real; however, other things being equal, a straight reach is probably the best location. The writer's experience leads him to the following conclusions:

There should be guide piers, both above and below every lock, placed an angle of about 10° with the axis of the lock. Where there is much disturbance below the dam during periods of high water, the lower pier should extend from the lower end of the river wall. Solid

Mr. Andrews. piers not less than 150 ft. in length, and longer where the volume of traffic is considerable, with drift passages at the lock wall, are preferable to pile clusters.

Rack bars for maneuvering lock gates are objectionable in rivers carrying much drift, for they have to be removed when the lock is about to be submerged, and replaced when it emerges. The maneuvering apparatus described by the author is not open to this objection, and, as the writer knows from experience, is in other respects a most admirable arrangement.

The design of the dams at Locks Nos. 1, 2 and 3, Black Warrior River, is bad, on account of the stepped lower slope. Drift passing over the dams would cause the displacement of the slope stones, and entail constant expense for repairs. A better arrangement is that in which the stones are set with the beds normal to the slope, as at Lock No. 4 of the same river. Dams of this type, *viz.*, crib-filled dams with a lower slope of stone should have the lower slope laid without cement beds or joints, thereby allowing the free passage of leakage. The face, whether of masonry or sheet-piles, should be made water-tight, or as nearly so as possible; but in rivers of considerable low-water discharge, it is not the part of economy to go to any great expense to secure a water-tight face. As usually designed, it is only necessary to maintain the surface of the pool at the crest of such dams. The low-water discharge not needed for that purpose may pass the dam as leakage. This last statement does not apply, of course, to dams intended to develop power.

The writer has recently repaired and raised to a height of 15 ft. (the height being originally 12 ft.), a crib-filled dam, 700 ft. long, built on a foundation of gravel, mud and rotten limestone. The repairs and addition to the height were made by building a heavy stone slope from below and over the crib, or what was left of it. The stones in the slope contained from 1 to 3 cu. yds. each, and were laid dry with the beds normal and the faces flush with the slope. The face of the dam was of double-lap, 4 x 12-in. and 2 x 12-in. sheet-piling. The sheet-piling extended 5 ft. above the crest, as a protection bulkhead to the workmen below. After the slope below was finished, the piling was cut flush with the crest. The operation was repeated until the dam was finished. Quarry waste was filled in against the sheet-piling from above. No attempt was made to get a water-tight face, the low-water flow being sufficient to maintain the upper pool at the crest, with the leakage allowed. An apron at the toe, to prevent scour, was built of large stones roughly placed, and the interstices were filled with smaller stones. The work was done by hired labor, and cost, every expense included, \$2.51 + per cubic yard.

As to the expediency of the improvement of our rivers, opinion is as diverse as it once was concerning the proper gauge for our railroads,

and it seems that the arguments for and against are likely to be as vigorously presented as were those fought over in the days of the "Battle of the Gauges." Mr. Andrews.

The writer can do no more than generalize, not having statistics at hand, but he ventures the assertion that, should the Erie and Welland Canals be abandoned, freight rates from the West to New York would go soaring, and New Orleans would become the chief shipping point for the export trade of the country. He is aware that pages upon pages of statistics have been printed showing that the railroads entering New York from the West can and do carry freight as cheaply as the same is transported through the canals; but those statistics being presentations of facts make no prediction of the probable effect of an abandonment of the water lines of transportation from the Great Lakes to the Eastern Coast.

The writer recently had some machinery shipped to a point on the Lower Mississippi River, a part coming from Bridgeport, Conn., and a part from Birmingham, Ala. The freight rate from Bridgeport was practically the same as that from Birmingham, because Bridgeport, though the length of haul was against her, had the advantage of continuous water transportation.

Statistics of this kind interest the people at large, and, as long as conditions remain as they are, there will be a demand for the improvement of our rivers, though argument be piled upon argument showing that railroads can be built, operated and maintained, at far less cost than the cost of improving, and maintaining the improvement of, our rivers.

R. C. McCalla, M. Am. Soc. C. E. (by letter).—The writer feels gratified that his paper has brought out an able and interesting discussion of a subject on which the literature is rather scanty, considering the number of important works of this character in the United States and other countries. He hopes to profit by many of the ideas and arguments advanced. Mr. McCalla

Location.—The Warrior is a narrow, crooked stream. There are very few straight reaches and few or no places wide enough to take in the lock and abutment and a dam long enough to provide sufficient spillway for the proper discharge of flood waters. The width of the stream at low water varies from 100 to 300 ft. and averages about 200 ft., therefore the locks and abutments must be set well back into the banks. If straight reaches were available for locations, curved approaches leading back into the stream would be required at both ends of the lock. If locations were made in bends and on the concave shore, still sharper or longer curves would be required in the approaches to get back into the stream.

Wherever a lock is located, it forms a barrier to the current, and thereby causes silt deposits in the lock and approaches; also, during

Mr. McCalla. rises there must be a strong off-shore current above the lock toward the "suck" of the dam. The deposit and off-shore current are both somewhat worse on a convex than a concave shore. With locks in the bends and on the convex shore, straight approaches parallel to the axis of the lock are secured, and they re-enter the stream within a short distance.

During about eight months each year the pools are like ponds, without current; and, certainly, during that period, straight approaches would be better for navigation. At times during the other four months, wherever the locks are located, it will be dangerous to enter from above without putting a line ashore, and snubbing posts will be placed along the banks for this purpose.

Vast quantities of drift are borne by floods. At times the writer has seen the drift so thick that it looked almost as though one could walk across the river on it. This drift is constantly becoming water-logged and dropping to the bottom in eddy water. Concave shore locations would place the locks right in the path of this drift, and would cause much of it to accumulate in the locks during floods. It will probably be easier to pump out silt than to remove a combination of silt and drift.

All things considered, the writer believes that, for this system of rivers at least, a convex shore in a bend of long radius gives the best location for a lock.

Dams, Lift, Guard, Etc.—The question of fixed or movable dams admits of many arguments on both sides. Movable dams are at best rather frail structures. Tows on the Warrior will always be small, and will require from one to two lockages, only, to pass a lock. Movable dams would have to be kept up about nine months per annum, and would have to be raised occasionally during the other three months. Therefore, to navigation, the saving of time from the use of movable instead of fixed dams would be small. Probably no form of movable dam except the needle-dam is sufficiently tight to hold the low-water flow of the Warrior; and a serious objection to the needle-dam is that the needles must be taken out of the river and stored when the dam is lowered, and brought back when the dam is to be raised.

The Warrior and Tombigbee are both quite flat, and all the indications are that fixed dams of 10 ft. lift and proper length will drown quickly during floods and exert little or no influence on maximum flood heights. The dam at Warrior Lock No. 6 was completed during September, 1902, and a small rise occurred during the following month. Daily gauge readings at 7 A. M. during the rise are shown in Table No. 15, the zero of both gauges being the lower miter-sill, Elevation = 74.5, and the crest of the dam being 16.5 ft. above zero, or Elevation = 91.0:

TABLE No. 15.

Mr. McCalla.

Date.	Above the dam.	Below the dam.
Oct. 11	18.51	9.00
" 12	20.25	15.00
" 13	20.60	17.20
" 14	19.70	14.20
" 15	18.85	11.20
" 16	18.29	9.20
" 17	17.99	7.90
" 18	17.70	7.05
" 19	17.60	6.80
" 20	17.50	5.87

Dam No. 5, seventeen miles below, the crest elevation of which is 81.0, was nearly completed at the time. Part of the rise went over this dam and part through the chamber of Lock No. 5, where the gates had not been erected. It will be noticed that the lower pool gained quite rapidly on the upper pool at Lock No. 6, and, had the rise continued, the two pools would probably have reached approximately the same level several feet below the top of the lock walls. Of course, on a more rapid rise, the lower pool would not have gained so rapidly on the upper pool, but it is thought that the maximum difference in pool levels when the lock walls become submerged will be about one foot, and that this will occur very rarely.

In the Warrior River the principal objections to concrete dams on pile foundations are the cost and the danger of "blow outs" underneath. It is believed that the stone filling in the crib dams, resting directly on the river bed, will settle and choke a leak before it can become large, and that thus the danger of "blow outs" is reduced to a minimum.

The object of caulking the sloping sheathing is to prevent streams of water from trickling through the stone filling, carrying the sand and gravel out of the interstices, and thus reducing the weight of the filling. Weep holes are provided in and near the down-stream face to relieve the sheathing of dangerous up-thrust. So far, there is apparently very little leakage through or under Dams Nos. 5 and 6, which are the only ones of this type completed on these rivers.

Scour is expected below the dams during floods, and it is to be guarded against by heavily rip-rapping the bed of the stream below the apron and along the back of the river wall and the face of the abutment.

Sheet-Piling.—Sheet-piling 6 ins. thick was found to be rather light for hard driving, and on future work 9-in. piling is to be used almost entirely. Each pile should be built of three pieces extending the full length of the pile, and the center pieces should be dressed to uniform thickness to reduce leakage. The best width of tongue for piles built

Mr. McCalla. of 3 x 12-in. planks seems to be about 3½ ins., and great care should be taken not to injure the piles by hard driving, the combination of jet and short blows of a heavy hammer giving the best results. The heads of all piles should be protected by a Casgrain pile cap during driving.

Pumping Out.—Thus far, there has been no difficulty in pumping out the lock chambers with the coffer timbers in place, an 8-in. centrifugal pump being ample to control the leakage under ordinary conditions.

Sill Anchorage.—The miter-sills are held down by 1¼-in. bolts, 4½ ft. long, and spaced 3 ft. apart. Each bolt has an 8-in. cast washer on the bottom and a 4-in. wrought washer and nut on the top. The sills can hardly come up unless the walls come with them.

Maneuvering Gears.—The gate-maneuvering gears have been in constant use seven years on the Tuscaloosa locks, and have proved very satisfactory. A small boy can operate the gates with ease under ordinary conditions. The gears are simple, durable and efficient. They lie flat and close to the walls, and nothing has to be removed during floods except the lever, which is unshipped and laid down by the gears. The writer believes that this method is the most satisfactory now in use for the hand maneuvering of lock gates, and wishes to give full credit for the design to the late Horace Harding, M. Am. Soc. C. E., who was in local charge of these improvements for many years.

Stability of Walls.—The river wall is 6 ft. wide on top, 12.15 ft. wide at the base, and 29.5 ft. high, but rests on a concrete footing course, 14.25 ft. wide and 1.5 ft, thick, with a tight mortar joint between the base of the wall and the top of the footing course. Up-thrust in this mortar joint is not considered possible, and, therefore, the wall proper has a factor of safety, against overturning on the footing course, of about 6, with 17 ft. head outside and the lock chamber pumped out.

Up-thrust undoubtedly exists under the footing course, but the head must be reduced considerably while the water is percolating through or under the sheet-piling and through the sand and gravel underneath the wall on its way to the floor valves. Assuming an up-thrust due to half the maximum head distributed uniformly under the footing course, the factor of safety against overturning would be about 2.5, with 17 ft. head outside and the lock chamber pumped out.

With the water level in Warrior Lock No. 6, at Elevation 99, the water level in the lower pool should be about at Elevation 96 to 97, instead of 93.8, as assumed by Mr. Nelles. The gauge readings given in Table No. 15 illustrate the rapid gain of the lower on the upper pool level during rises.

The bank walls are believed to be perfectly safe under the worst possible conditions. With the lock chambers pumped out, fresh filling was placed behind the bank walls level with the top, and was

thoroughly saturated with water to assist settlement, the water standing in pools for days at or near the coping level. No evidence of settlement or movement of the walls can be detected. The bank walls are 6 ft. wide on top, stepping at the back to 16 ft. wide at the base, with steps 2 ft. wide and 5 ft. high. The footing course is 18 ft. wide and 1.5 ft. thick, projecting 1 ft. on the front and back. Both walls are 31 ft. high, including the footing course. Mr. McCalla.

Guide Walls, Masonry Floors, Etc.—Long guide walls above and below the lock bank wall, masonry lock floors, masonry dams (if they can be secured against "blow outs"), and other features of this character suggested by those discussing the paper, are excellent things, but they cost a great deal of money. If all these suggestions were adopted for these improvements, the first cost would be perhaps $10 000 000 instead of $5 000 000, and the time required for completion perhaps would be doubled also, because the biennial appropriations for a particular improvement are necessarily limited by the needs of the whole country and the funds available. At the present rate, eight to ten years will be required to complete the work, while the traffic is nearly all prospective, and, possibly, may never develop.

Under these conditions it is deemed to be to the best interests of the United States to complete the work as rapidly as practicable, and at the minimum cost. Betterments can be made as the traffic justifies them and as the old works wear out. Permanent guide walls of proper height and length would be very costly and would not be justified for a small and unimportant traffic. It would be better to let the boats put a line ashore occasionally. Temporary guide walls of timber cribs, or piles and timber, if built now, would rot down before the lock system is completed, and, therefore, before there can be much traffic. If temporary works of this character are to be used they should be built at about the time of completion of the permanent works. Besides, after the locks have been in use a while, the character of the guide walls, guard protection, etc., best suited to the needs of traffic and to local conditions can be determined better than now, for experience is an excellent teacher.

If the timber crib dams prove safe and satisfactory, but finally rot or wear out, they can be replaced with concrete dams on the old foundations, which should be thoroughly settled by that time. If the timber floors fail or wear out rapidly they will have to be replaced with more permanent construction.

If our pioneer railroad builders had adopted the policy of using nothing but the best and most permanent construction, nine-tenths of the United States would still be a wilderness. On the contrary, they built cheap lines into undeveloped territory, and improved their property as the territory developed and was justified by the traffic. The results have proved their wisdom abundantly.

Mr. McCalla. *Commercial Importance, Depth, Etc.*—The depth of the channel, or rather the 6-ft. draft of vessels, was fixed by Congress, and the engineers connected with the work are in no way responsible for it. It is certainly ample, however, for ordinary flat-bottom river steamboats, and for ordinary coal barges of 500 tons' burden.

Unlimited arguments can be made for or against the commercial importance of these improvements. That is a matter to be considered more especially by Congress than by the engineers on the work, except in so far as they are called upon by Congress for information. In the opinion of the writer the commercial value of the work will have to be determined finally by experience. If it regulates railroad freight rates in the region tributary to the improved rivers, and develops a large export coal traffic from Mobile, the public will be amply repaid for every dollar expended.

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PAPERS AND DISCUSSIONS.

THE FLOW OF WATER IN WOOD PIPES.

Discussion.*

By Messrs. Rudolph Hering, Gardner S. Williams and Theron A. Noble.

Rudolph Hering, M. Am. Soc. C. E.—The speaker believes this paper to be a useful contribution to knowledge, but regrets that the author has presented a new formula which he says fits his experiments very well, because the more formulas of this kind we get, the greater the confusion becomes in their application. If the application were always limited to exactly the conditions which the author had before him, the formula would be good, without question. But, when getting into textbooks, and when applied in general practice, they are often disconnected from the original data from which the formulas are developed, and unless we are within the original range of experiments their use becomes dangerous. Mr. Hering.

The speaker was once very forcibly struck with the importance of this fact by a formula suggested for pile-driving by one of our most prominent engineers, and found in at least one textbook. When applying it, it gave negative results in connection with the case in hand, which was quite an ordinary one; that is, the harder the pile was pounded, the less its firmness—according to the formula. When any one produces a new formula, the fact that it applies only to his own experiments or investigations should be emphasized, and the limits should be given as a part of the formula, just as limits are given when the integral calculus is used.

* Continued from October, 1902, *Proceedings*. See August, 1902, *Proceedings*, for paper on this subject by Theron A. Noble, M. Am. Soc. C. E.

Mr. Williams. GARDNER S. WILLIAMS, M. Am. Soc. C. E.—To judge from the limited number of discussions presented, it seems that the merits of the paper under consideration have been but lightly appreciated.

Anyone who studies the literature upon the flow of water in pipes will be impressed first of all by the wide gaps existing between the sizes used in the several experiments, the data of which are available, and then by the number of experiments that must be rejected from a classification intended to include only the thoroughly reliable.

On wooden stave pipe, naturally, from its comparatively recent introduction, only a very limited number of experiments has been thus far conducted, and of these, the most extensive series appears to have been influenced by conditions beyond the control or conception of the observers, to such an extent as to render the results obtained, if not erratic, at least so variable and unconformable to any apparent law that their critical study leaves one in very great doubt as to their general applicability. It is doubtful if anyone, outside of the experimenters themselves, has spent more study than the speaker upon those experiments, and certainly no one has striven more faithfully to glean from them some measure of information generally applicable to the flow of water in pipes, but thus far the Ogden Experiments* have stood at the extreme end of a series, far removed from all others, and presenting results widely different from everything approaching them; and the only way to explain them has been to say that somewhere between the conditions of ordinary-sized pipe and those of a 6-ft. conduit the laws of flow are subject to a marked change.

The experiments described in Mr. Noble's paper bring the data much nearer to the Ogden size, and it is important to notice that there is in them no indication of an approach to the Ogden eccentricities, but they conform to the indications of other standard experiments and show that the carrying capacity of wooden stave pipe is considerably higher than the Ogden results would lead one to expect.

But, aside from this, one of the most interesting features of the investigation is the light it throws upon the inapplicability of the long-honored law that loss of head varies as the square of the velocity. Ever since the days of Du Buat, Eytelwein and Prony, many investigators have, from time to time, pointed out that this law was not strictly applicable to the flow of water in pipes. In 1808, Dr. Thomas Young suggested, in an address to the Royal Society,† that this exponent was more nearly 1.8, although he inclined decidedly to the view that there were two functions of the velocity involved, one varying as the square and one as the first power. Later, in 1855,‡ Thomas Hawksley made

* *Transactions*, Am. Soc. C. E., Vol. xl, p. 471, and xliv, p. 84.

† *Philosophical Transactions*, 1808.

‡ *Minutes of Proceedings*, Institution of Civil Engineers, 1855.

an extended exposition of the same view, and in 1873 Dr. Lampe* presented his experiments on the Danzig pipe line, with his well-known formula, $V = 203.3\, r^{0.694}\, s^{0.555}$. During the last ten years numerous investigators have suggested various exponents other than 2 for V, and some time ago the speaker himself presented, to the Detroit Engineering Society, a discussion of the past experiments on small pipes bearing upon this question.† Starting with the formula $H_f = m\,V^n$, which is about the simplest expression for the flow of water, m and n being constants for any given pipe line, he attempted to discover what effect, if any, there was upon the exponent n due to changes of diameter, alignment and character of interior surface. From an investigation of more than eighty different series of experiments by thirteen different observers, certain conclusions were drawn regarding the variation of n which seemed clearly established by these data, and the principal ones were: Mr. Williams.

That n increases as the diameter increases, from about 1 in capillary tubes to about 2 in large pipes, being from 1.80 to 2 in those ordinarily used by the engineer.

That n increases as roughness increases.

That n decreases as curvature increases.

That n is different for different materials, being lowest for tin and brass.

This investigation having shown the desirability of a series of experiments upon pipes of the same material and different diameters under similar conditions, such a series was begun at the Hydraulic Laboratory of Cornell University by A. V. Saph, Assoc. Am. Soc. C. E., and E. W. Schoder, Jun. Am. Soc. C. E., and, to date, observations have been made upon pipes of seamless brass tubing, ranging from $\frac{1}{10}$ in. to $2\frac{1}{10}$ ins. diameter. As stated in the discussions by those gentlemen, these experiments show n to be practically constant for all of the series and approximately 1.75.

The experiments of the author, when discussed logarithmically by the formula $H_f = m\,V^n$, also give for the value of n about 1.75, a result which, taken with that of the Cornell Experiments, seems to establish this value pretty clearly as the correct one for smooth pipe, and proves in error the speaker's conclusions, previously mentioned, that n changes with the diameter, as it shows that as long as the pipe remains smooth n does not change. When, therefore, starting with a diameter of $\frac{1}{10}$ in. and going to a diameter of 54 ins., including the Adams experiments on 14-in. stave pipe, the exponent is found to remain constant at about 1.75, what is to be said for an exponent of 196, when a 72-in. pipe is reached?

* *Der Civilingenieur*, Vol. xix, 1873.

† *Journal*, Association of Engineering Societies, March, 1901, p. 169.

Mr. Williams. Some two years ago a series of experiments was made at Detroit* upon a very perfect line of 12-in. pipe. There was a tangent of about 3 200 ft. that was as straight and true to grade as pipe can be laid, and, when this formula was applied to the experiments upon it, the exponent of n was found to be 1.78. The cast-iron pipe experimented upon by Darcy gave $n = 1.93$ to 1.97, and it will be recalled that, in the experiments upon the Rosemary Syphon†, Desmond FitzGerald, M. Am. Soc. C. E., found n to be 1.91 for the cleaned 48-in. pipe, and 2.03 while the pipe was roughened by tubercles.

It is evident that in measuring lengths in diameters there are more joints, and, hence, greater roughness, in large than in small cast-iron pipe, and from the fact that the ordinary experiments upon it give n a value of about 1.90, the effect of careful laying is shown in the Detroit pipe, and the cause of the speaker's misconception of the true law is at once apparent, for, in drawing the conclusions above stated, the most complete series used was of cast-iron pipe, and in this, for the above reason, the exponent does increase with the diameter, though, as it now appears, not by reason of the diameter, but by reason of the joints and consequent roughening of the walls.

The experiments of the author show a high degree of consistency when examined carefully, and indicate very good experimental work. If there were an error in the rating of the meter the error is carried consistently through each series, and if there were errors of levels or observations they were consistent errors, for there are no erratic results to be accounted for, and it seems unlikely that the relations indicated between H and V, so far at least as n is concerned, are misleading by more than a very small percentage. It is unfortunate, however, that the author himself did not apply the formula $H_f = m\ V^n$ to his results, for, had he done so, he would not have presented the complicated expressions on pages 503 and 504,‡ or the table on page 505‡ in which the value of his own experiments is to a considerable extent masked by an attempt to make them conform to the less reliable results obtained at Ogden. The presence of the intercept or subtractive term in these formulas indicates that the exponent of V is not 2, as has been shown by the speaker in the discussion already referred to.§

The speaker would call attention to Table No. 3, and offer a word of caution as to the applicability of the results therein presented. While these data undoubtedly give a correct representation of the losses of head observed from one side to another of the specials in question, those results come far short of indicating correctly the resistances actually caused by them. The actual losses may be either greater or less than shown by the figures given, for the reason that the

* *Transactions*, Am. Soc. C. E., Vol. xlvii, p. 159.

† *Transactions*, Am. Soc. C. E., Vol. xxxv, p. 258.

‡ *Proceedings*, Am. Soc C. E., August, 1902.

§ *Journal*, Association of Engineering Societies, March, 1901, p. 170.

disturbances of flow thus generated extend with corresponding losses of head for many diameters beyond the special causing them; and piezometric indications within the region of disturbance are not comparable with those taken before disturbance has begun. The only method thus far known to the speaker of determining correctly such resistances is by comparing the losses in sections of straight pipe without such specials with those of other sections containing them. The speaker and his associates in the Detroit Experiments were led to the same attempt at the determination of these losses as the author has made, but they found the results thus obtained anomalous, and the experiments described by Messrs. Saph and Schoder* threw such additional light upon the matter that in their final discussion of the Detroit Experiments the authors went to considerable pains to re-compute the various losses of head, according to the plan proposed above, the results being presented in tabular form,† and showing quite decided differences from those obtained by direct observation. Mr. Williams.

THERON A. NOBLE, M. Am. Soc. C. E. (by letter).—In the experiments on "The Flow of Water in Wood Pipes" the main effort was expended in eliminating sources of error and in making the experiments as complete as the time and facilities available would permit. That sufficient study was not given to the results was due to lack of time. It is rather a serious loss of time to a practicing engineer to undertake such an extended series of experiments. Mr. Noble.

The writer believes, with Mr. Hering, that an excess of formulas, like an excess of advice, is apt to lead to wrong conclusions. It is very bad practice, however, to cling to old methods when they have been found to be cumbersome and inaccurate. If the innumerable experiments are to teach us nothing of the laws of motion of water in pipes, we are losing their main value. By a careful study of these experiments the writer believes that a reliable formula is to be had for each particular kind of pipe, within certain ranges of velocity and diameter.

In the case of wood pipes, the number of experiments available is not all that could be desired to determine the relation between velocity, friction head and diameter, but a formula can be determined which will fit three out of four of the experiments, and determine the values of V, H_f or D, well within the limits of ordinary practice. This formula applies to wood pipes from 14 to 72 ins. in diameter, and friction heads from 0.2 ft. to 2 ft. per 1 000 ft. This is certainly a step in advance.

A similar study of the experiments on cast-iron and other pipes, the writer believes, would give similar results, with a somewhat different relation between D and the constant coefficient e'.

* *Transactions*, Am. Soc. C. E., Vol. xlvii, p. 317.

† *Transactions*, Am. Soc. C. E., Vol. xlvii, p. 360.

Mr. Noble. Kutter's formula, which was particularly designed for the flow in open channels, is wholly inadequate for use in calculating the flow in circular pipes, for the following reasons:

The coefficients, c or n, are found to change very radically with both the diameter and velocity, thus making it necessary to consult tabulated values of these constants for different diameters and velocities in order to get results at all satisfactory. It involves a wholly unnecessary determination of the mean hydraulic radius, R, since R is the diameter times a constant multiplier, which could just as well appear in the coefficient.

In a paper* by George H. Fenkell, Jun. Am. Soc. C. E., he shows by diagrams the results of all the more reliable experiments conducted on various kinds of pipes, showing any considerable range of velocities. All these observations, in each experiment, he has plotted on cross-section paper, showing the relation between velocity head and friction head. In all these diagrams this relation conforms very closely to a straight line for the observations on any single size or kind of pipe. The deviation of any one of these observations is probably within the limit of error due to taking observations or making calculations. The same is true of the two experiments conducted by the writer. This relation between H_v and H_f gives a reliable basis for determining the relation between D, in the formula, and the value of the constant.

Starting with Mr. Fenkell's general formula for the relation between H_v and H_f:

$$H_f = a\,H_v \pm b \qquad (7)$$

In which H_f = Friction head, in feet per 1 000 ft.;

H_v = Velocity head $= \dfrac{V^2}{2g}$;

a = A constant, which remains constant for different velocities, but is different for different values of the diameter, D;

b = A constant of small value, which Mr. Fenkell attributes to some error, but which is more probably due to the causes mentioned by Professor Merriman.

Substituting the value of V,

$$V^2 = \frac{2g}{a}\,(H_f \pm b)$$

$$V = \sqrt{\frac{2g}{a}}\,\sqrt{H_f \pm b} \qquad (8)$$

The value of $\sqrt{\dfrac{2g}{a}}$, as shown in Formulas 1, 2, 3 and 4, is as follows:

* *Journal*, Association of Engineering Societies, March, 1902.

Mr. Noble.

Size of pipe, in feet.	$\sqrt{\dfrac{2\,g}{a}}$
1.171	1.9463
3.708	3.6895
4.5156	4.4405
6.042	4.9232

For wood pipe of any given size, $\sqrt{\dfrac{2\,g}{a}}$ is constant, and, therefore, is independent of the value of H_f, or V, but increases by some unknown relation with D.

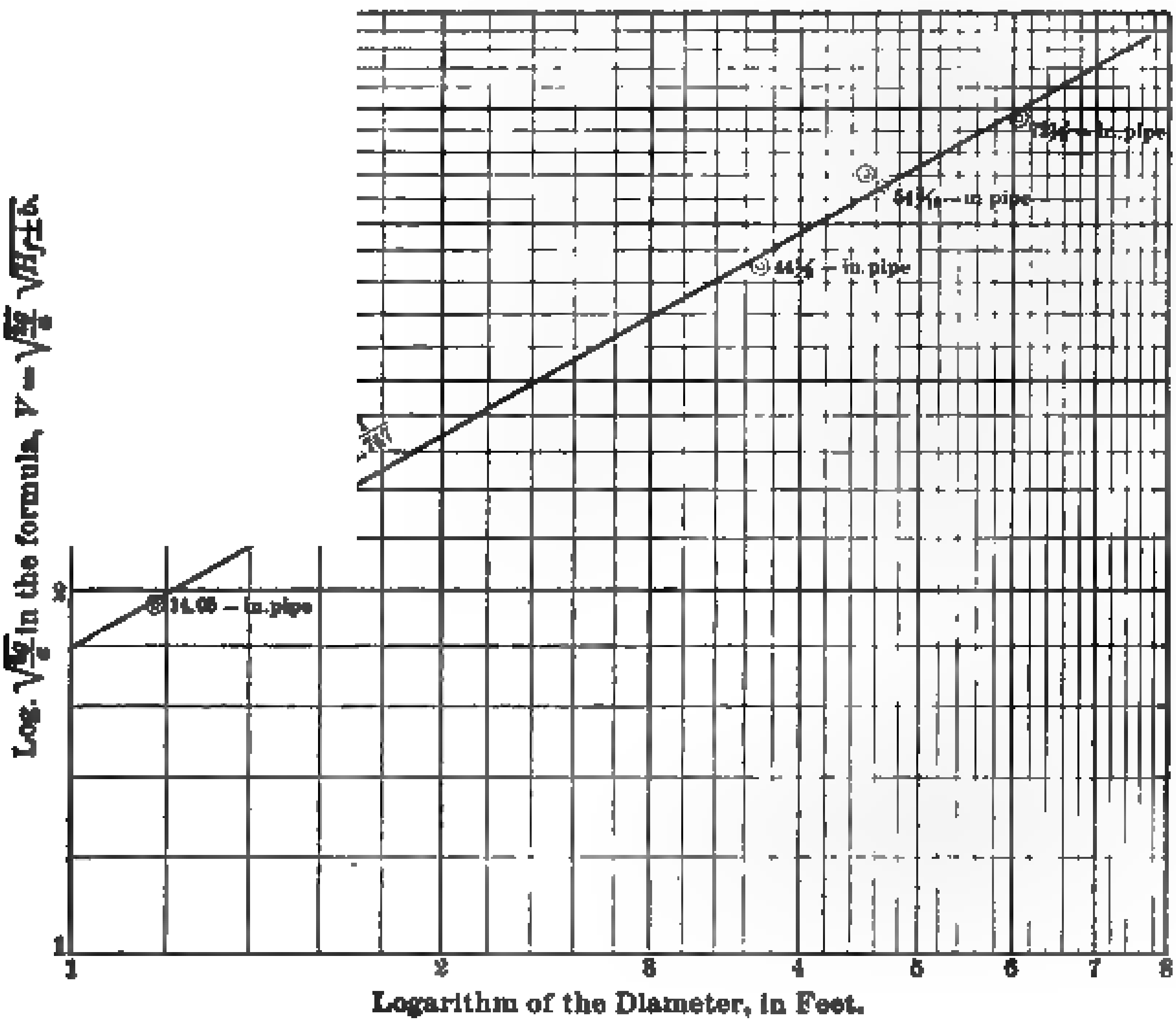

FIG. 13.

It will be seen (page 505*) that the assumption that $\sqrt{\dfrac{2\,g}{a}}$ varies as $\sqrt{D}$, is not correct, as the resulting values of e are not constant for different sizes of pipes.

Is there any other power of D which, multiplied by a constant, will give the correct values of $\sqrt{\dfrac{2\,g}{a}}$ for the different sizes of wood

* *Proceedings*, Am. Soc. C. E., for August, 1909.

Mr. Noble.

pipes experimented upon? If so, the values of $\sqrt{\frac{2g}{a}}$ and D, plotted on logarithmic paper, would appear in one straight line. In the diagram, Fig. 13, these quantities have been thus plotted.

As will be seen, in three out of four of these experiments, the plotted values of $\sqrt{\frac{2g}{a}}$ and $\sqrt{D}$ conform to a straight line very closely. Drawing the line through the points for the 14-in. pipe, and the center of gravity for the other three sizes, the value of the exponent of D becomes $\frac{1}{1.747}$, and Formula (8) becomes

$$V = e' D^{\frac{1}{1.747}} \sqrt{H_f \pm b} \qquad (9)$$

To determine the value of e':

$$V = e' D^{\frac{1}{1.747}} \sqrt{H_f \pm b} = \sqrt{\frac{2g}{a}} \sqrt{H_f \pm b}$$

$$e' D^{\frac{1}{1.747}} = \sqrt{\frac{2g}{a}}$$

$$e' = \frac{\sqrt{\frac{2g}{a}}}{D^{\frac{1}{1.747}}} \qquad (10)$$

The values of e, as used in Formula (5), and e' in Formula (9), for pipes of different sizes, are:

Diameter of pipe, in feet.	e	e'	Deviation of e' from 1.76
1.171	1.799	1.777	+ 1 per cent.
3.708	1.916	1.742	− 1 "
4.5156	2.089	1.873	+ 6.4 "
6.042	2.003	1.758	− 0.01 "

With the exception of the 54-in. pipe, the value of e' does not vary more than would be expected, from errors in taking observations, etc. Better results could not be obtained without more perfect similarity of conditions and more accurate methods of measurement, and these are quite close enough for general engineering practice.

The writer feels satisfied that there is some error either in the measurements or the conditions in the 54-in. pipe experiments, and, some time in the future, hopes to conduct a series of observations on that portion of the pipe which is comparatively free from distortions, and by methods which will give more accurate measurements of piezometer heights.

In Fig. 14 the curves for Formula (9), with $e' = 1.76$, are drawn for the four sizes of pipe experimented upon. The greatest variation from this curve is in the 54-in. pipe. In the case of the other three

the observations are close enough for ordinary engineering practice, thus proving that the formula could be used (within the limits hereinafter mentioned), and be within a probable error of not more than 2 per cent. Mr. Noble.

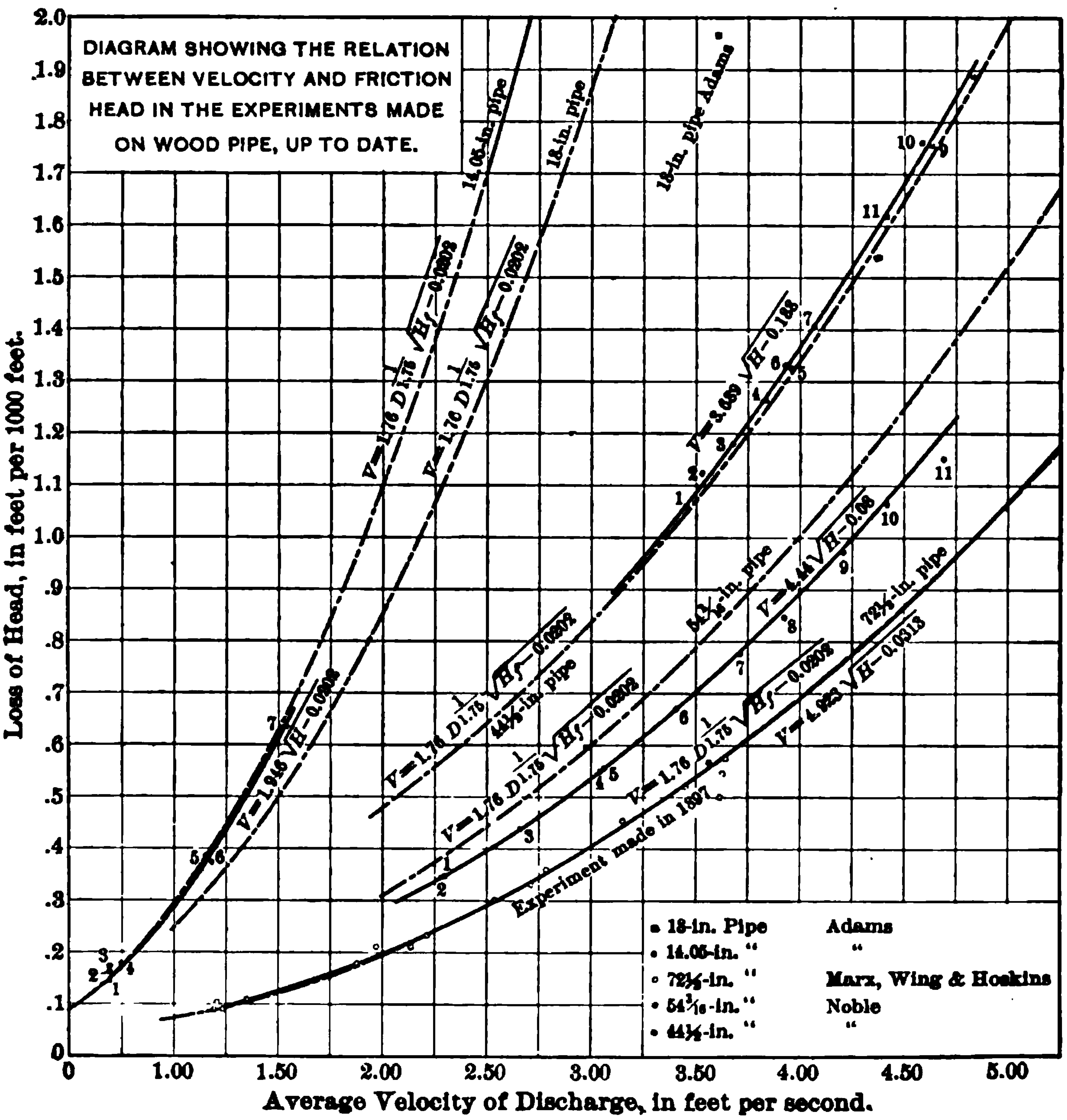

FIG. 14.

In Mr. Schoder's discussion, in plotting the velocity and friction head on logarithmic paper, the observations at the higher velocities are bunched together in such a manner that it is not possible to determine the slope of the line with much accuracy. In the writer's opinion, Mr. Fenkell's diagrams prove, beyond question, that H_f varies as the square of the velocity.

This would seem to be a natural conclusion, from the laws of gravity. Whatever other influence there is on the friction head would be due to the diameter or the nature of the surface of contact. The effect of friction in the pipe is to reduce its effective diameter, which

Mr. Noble. is accounted for in the value of the exponent $\frac{1}{1.747}$. The difference between Mr. Schoder's conclusion, as to the exponent of H_f (1.73), and the writer's is perhaps due to the fact that the writer has accounted for this variation in the diameter rather than in the velocity.

In answer to Mr. Saph's contention that the height of Piezometer A is probably influenced by the curves just preceding: Any influence of this nature would be felt in the well and at Piezometer A equally. There are no means of detecting any influence of this nature without taking observations on straight and curved portions of the pipe simultaneously. It is possible that this influence may account for the lack of conformity of the 54-in. pipe experiments with the others, though the writer does not believe that such an effect exists, as the effect of curves should be to increase rather than decrease the friction head; and it seems hardly possible that long easy curves could increase the velocity 6 per cent.

As will be seen in Fig. 14, the single observation of the flow in 18-in. pipe shows a very serious difference from the results obtained for other pipes, showing again higher velocities.

As the result of careful study of these experiments, the writer feels justified in drawing the following conclusions :

1.—That within the range of these experiments, from 14-in. to 72-in. pipes, and between friction heads of 0.2 ft. and 2 ft. per 1 000 ft., the friction head, H_f, varies as the square of the velocity.

2.—That the velocity varies as some odd exponent of the diameter. In three out of four experiments this exponent is very nearly $\frac{1}{1.75}$.

3.—That it would require a series of experiments on pipes of different diameters and velocities covering a wide range, made under identical conditions, to determine this exponent accurately.

4.—After this exponent has been determined, the flow in perfectly straight and smooth pipes follows a definite law. That the general expression for this law, as determined by the writer, is

$$V = e' D^{\frac{1}{n}} \sqrt{H_f \pm b}.$$

5.—That the formula which conforms very closely to three out of four of the experiments is

$$V = 1.76\, D^{\frac{1}{1.75}} \sqrt{H_f \pm b}.$$

6.—That the use of this formula will probably give results within 2% of true values.

It is probable that, by a set of very accurate experiments made at low velocities, the value of b may be zero, and that the constant e' and the exponent of D may be changed somewhat to make the formula conform to the experiments.

The amount of thought and attention that Mr. Williams has given the subject of the flow of water in pipes makes his discussion a valuable addition to the paper. The writer has had neither the time nor the facilities to go as deeply into the subject, from the standpoint of what has been done with other kinds of pipe, and, in the paper and discussion, has confined his attention exclusively to the kind of pipe and within the range of sizes which these experiments covered. His object has been two-fold: To furnish the data in its original form, with all steps in the calculations, so that it could be fully discussed and utilized; and to put the results of the only experiments conducted on wood pipe in such form that the practicing engineer who has use for data of this nature could calculate the flow for any intermediate size or slope and feel satisfied that the results of his calculations would conform to the reliable experiments extant. Mr. Noble.

Whether the velocity varies as an odd exponent of the diameter or of the friction head is a question as to the manner in which the formula is derived. That the velocity should vary as the $\frac{1}{2}$ power of the head, and that the diameter should vary as some odd exponent with the velocity, would seem to the writer to be most conformable.

What Mr. Williams says in regard to the experiments on loss of head in specials is undoubtedly true. The original data were given to demonstrate that there could not have been in these specials any resistance that would affect materially the total friction head in the lengths of pipe experimented upon, the object being to eliminate a probable source of error.

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PAPERS AND DISCUSSIONS.

THE PROTECTION AND IMPROVEMENT OF FORESHORES BY THE UTILIZATION OF TIDAL AND WAVE ACTION.

Discussion.*

By Messrs. L. M. Haupt, Francis L. Pruyn, E. Burslem Thomson and F. Collingwood.

Mr. Haupt. L. M. Haupt, M. Am. Soc. C. E. (by letter).—The subject presented for discussion is as old as the sea, and it has forced itself upon the attention of all denizens of alluvial coasts for centuries. Many efforts have been made to resist the attacks of Neptune, but they have been disconnected, impulsive, empirical, and generally useless. In a few notable instances, systematic, persistent, national efforts have resulted in fixing permanently the littoral boundaries, as in Holland and Belgium. Not many years ago it was cheaper in the United States to retreat than to fight the sea. Now, in many instances, it is not so, and the method suggested by Mr. Case, and so admirably presented in this paper by his successor, is based upon the general scientific principle that all materials have a definite angle of repose under certain conditions. This, for a foreshore slope, is claimed to be an ellipse having co-ordinates which must vary as the resultant of all the forces varies. To ascertain the intensity and direction of this resultant is the

* This discussion (of the paper by R. G. Allanson-Winn, M. Inst. C. E., I., printed in *Proceedings* for August, 1902), is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.
Communications on this subject received prior to December 26th, 1902, will be published subsequently.

Fig. 1.—A Low Groyne at Belmar, N. J., showing Drift.

Fig. 2.—Wreck within Breaker Line, at Seaside Park, N. J.

difficult part of this problem, and it is just here that the skill and experience of the engineer are called into vogue. Mr. Haupt.

The author cites a number of instances where the groynes have been built with great success, and he is correct in designing the work of recovery to operate little by little, making it cumulative. Abrupt angular changes in the direction of littoral currents invite scour and destruction, not deposit and reclamation. The spurs so frequently built at seaside resorts to confine a traveling beach may impound the sands in their bays temporarily, but they invariably show the saw-toothed indentations resulting from the windward side being filled to the crest and the leeward deeply scoured out, so clearly shown in Fig. 1, Plate XXXIX, which is a view of a low groyne at Belmar, on the North Jersey Coast. Similar features are shown in the writer's paper, "Littoral Movements of the New Jersey Coast, with Remarks on Beach Protection and Jetty Reaction,"* wherein the directions of the resultants were stated and the guide to them assigned.

The author mentions eight points which are factors in the problem, and yet there seem to be others, of even greater importance, which must not be overlooked, viz., the general as well as the local contour of the shore, and particularly the prevailing angle of wave approach.

The writer does not understand how samples of the amount of sediment carried by the currents are to be taken, at the surface and at the bottom within the breaker line, for each breaker appears to charge itself with a different amount, depending upon the height of its fall, the depth of the receding undertow, the character of material, and other conditions. This is the belt where the erosive forces are most active and where the greatest translation of drift occurs.

The causes of scour at local points are frequently occult, and may be traceable to distant shoals at sea, as the author suggests, but there is one form of foreshore protection to which little or no attention has been given, further than the reference to "Detached or Insular Wave Breakers," in the paper by the writer previously mentioned, where attention is directed to the influence of detached natural features forming strands in their lee in many cases. A recent striking illustration of this action is shown by a wreck which occurred early in 1902, at Seaside Park, N. J., just within the breaker line. In a few months the shore has advanced to the wreck, so that, even at high water, it is possible to walk to it dry shod, as shown in Fig. 2, Plate XXXIX.

In many foreshores there will be found, beyond the breaker trough, a well-defined ridge line, parallel with the coast, and rising above the general floor of the sea. This natural rampart is the proper place for such detached defences or outposts placed within covering distances so as to create a lee. Projecting groins invariably cause erosion at

* *Transactions*, Am. Soc. C. E., Vol. xxiii, p. 123.

Mr. Haupt. points below them, unless placed so as to deliver the littoral current nearly tangentially.

The largest piece of systematic reclamation with which the writer is familiar is that at Longport, N. J., where Mr. M. S. McCullough has built an extensive series of sand fences at a very small cost. These have had the effect of impounding a large amount of drift. In many places the beach has been filled from 6 to 8 ft., and the high-water line thrown back several hundred feet. The writer will reserve the details of this interesting work for a subsequent paper.

Mr. Pruyn. FRANCIS L. PRUYN, Assoc. M. Am. Soc. C. E. (by letter).—The question of shore protection is such an important one to all property owners along the entire coast of the United States that this paper is of great interest. Those who have tried to investigate the subject, and have been met with the total lack of literature on the question of shore protection, cannot help but feel grateful that at last this interesting branch of research has been given intelligent attention and study, and that the results have been published.

The proper treatment of the Jersey shores, which are subject to constant change by the erosion of strong littoral sea currents, has been a subject of some study on the part of the writer for the past few years.

From Sandy Hook to Atlantic City the condition of the beach seems to be more or less unstable. The sand is built up or washed away in an uncertain manner, so that to locate cottages near the shore is often a rather dangerous proceeding. At Long Branch the sea has made almost steady encroachment, and valuable hotels and cottages have frequently been endangered, necessitating the costly procedure of moving the structures further back from the ocean. When visited by the writer several years ago, this beach, at several points, had almost disappeared, and the high tide washed up against a low bluff which was protected by strong, heavy bulkheads and occasional pile-groynes. He was told that there had formerly been a wide beach at this point, where now appeared nothing but a hideous bare earth bluff. This also was gradually being eaten away. At other points on the coast, with which the writer is familiar, hotels and cottages have been moved back from the ocean two or three times during the past five years. The protection of the whole Jersey coast seems to be left to the judgment of the local contractor, who follows the rules laid down by his ancestors and never becomes discouraged by the failure of his devices. The systems are all similar, and consist of pile-groynes, spaced from 300 to 500 ft. apart, running from about high tide to low-water mark. In the better class of work they consist of two rows of piles jetted down 15 to 20 ft. below, and rising usually 4 to 5 ft. above, the beach surface. The piles are fastened together securely by bolts and waling strips, and are frequently sheeted on both sides with 3-in.

plank, spiked on. The sheeting is to prevent wash through the piles, which would be disastrous to the beach, as the sand on one side of the groyne is frequently from 3 to 4 ft. higher than on the other. The sheeting is usually creosoted, to retard the action of the *Teredo*, and, even then, lasts only three or four years. If the property to be protected is particularly valuable, and the erosion continues in spite of the groynes (which is frequently the case), a pile-bulkhead is driven, a little back from high-water mark and parallel to the beach. This double form of protection with bulkhead and groynes costs from $8 to $10 per foot run of beach, and is variously estimated to be replaced every five or ten years. Notwithstanding this heavy cost, as far as the writer's observations have gone, this system does not protect, after all. The erosion goes on, perhaps more slowly, but none the less steadily; the bulkheads are washed out by the winter storms; the houses are then moved further back; and the process begins all over again. In addition to this, the contour of the beach is unstable, and is constantly undergoing changes. At certain points it will be flat, firm and suitable for bathing; at others, steep, soft and totally unsuitable. The slope of the beach seems to be entirely beyond control. In an instance which came under the writer's observation this summer a costly bathing pavilion had been erected in the previous year, at a point where the beach was particularly favorable for bathing, and this year that portion of the beach was so steep that it was considered unsafe, on account of the undertow, and all bathing was done at a point some 3 000 yds. further up the beach. The same beach which the year before had been comparatively flat, and firm enough to support a bicycle at low tide, was now so soft, on account of its steepness, that in walking one sank in above the ankles. Mr. Pruyn.

The attractive qualities, and therefore the monetary value, of a flat, firm beach are of considerable importance to owners of seashore property, and its proper contour is only second in importance to the protection of the beach itself. As a matter of fact, a beach with a flat, uniform slope is the only stable beach, for it not only packs harder, but the retreating waves, having a minimum velocity, have lessened powers of destruction.

It certainly appears that the Case system of groyning approaches the problem in a scientific manner, and the writer is convinced that its application to the Jersey shores would procure admirable results. The building-up action begins, as the author remarks, at the foundation of the beach, *viz.*, at low-water mark, where the sand suspended in the currents is arrested by low groynes, and is carried up the beach and deposited by the wave action. The groynes, extending only to mean sea level, escape the heavy sea action that takes place above this point, and this is especially true of the heavy winter storms, the destructive action of which is so detrimental to the pile-groynes

Mr. Pruyn. and bulkheads; for these storms raise the mean sea level several feet above that usual during the summer months. The shorter length of the groynes is an element of economy in their construction, and this feature, combined with the light material of which they are built, makes their cost considerably less than the pile systems described above.

The adjustability of the system is one of its most favorable characteristics. What is aimed at is a slope of beach which will remain stable under the varying summer and winter currents; and, while this angle of repose may be approximated beforehand, it probably cannot be determined accurately for any particular shore, yet by actual observation in each case, as the boards are placed between the upright posts, one can determine when this angle of repose is reached, and the adding of further plank can be discontinued. The short length of time that each plank is exposed to the action of the *Teredo* before being buried by sand would probably not be sufficient to damage it materially, so that the frequent repairs which are necessary with the pile-groyne would not be required.

In closing, the writer desires to thank the author for the presentation of a paper on a subject which has received so little attention from the engineering profession, and hopes that a full discussion will bring to light many facts of interest to all those who have had to deal with the problem that presents itself when man endeavors to interfere with that enormous power, the sea.

Mr. Thomson. E. Burslem Thomson, Assoc. M. Am. Soc. C. E.—About six months ago the speaker, being in local charge of some work on the Atlantic Coast, was enabled to make some rather crude experiments illustrative of the value of this form of foreshore improvement.

It was necessary to construct a dam to check the encroachment of the sea across a narrow neck of land dividing the mainland from the ocean. The dam was 440 ft. long, and, in front of and normal to it, wings (or groynes) were thrown out, commencing 60 ft. from the face of the dam, at about mean high-water line, and extending seaward 100 ft. to about the line of mean low water. It was intended originally that these wings should be extended right up to the face of the dam, but, following a discussion on the Case groyne system with the principal engineer, it was decided that a space should be left between the dam and the shore end of the wings, thus allowing the waves and currents to pass freely around both ends. In construction, believing the main feature to be the gradual building up of a series of small obstructions, in place of the usual method of opposing a large obstruction to the formidable action of winds, waves and currents, the speaker made no effort to carry out the theoretical details of the Case system as to elliptical form, etc.

Five wings were constructed, 110 ft. apart, extending, as above

mentioned, from about mean high to mean low water. They were built of 3 x 8-in. yellow pine planks, dropped on edge and lightly nailed between posts set to receive them. As soon as the sand reached the level of the top of a plank, another was placed above it, and so on. The third tier of planks was recently set in place, and the sand is now within 2 ins. of its top. Mr. Thomson.

In some of the wings, the speaker noticed the tendency to the "saw-tooth" condition mentioned by the auther, but observed that this seemed to be dependent on the prevailing direction of the wind. A wind from the opposite direction would correct this condition in a short time, and at present there is no greater difference in elevation on either side than 2 or 3 ins.

The wings, being built on the shore at the entrance to the harbor, were subjected to tidal currents, the ebb and flood being of approximately equal velocity. Some of the posts supporting the planking were square timbers set about 3½ ins. apart and driven to a depth of 8 to 9 ft. with a pile-driver. The speaker found a more rapid, as well as a more economical, method in constructing them of two 3 x 8-in. planks, set 3½ ins. apart and kept in this position by nailing short cross-bars, in grillage form, at the lower end. This end was sunk 3 ft. in the sand, and, when the holes were filled and carefully tamped, the posts were found to be as firm as those driven by the pile-driver. Two men were able to construct and set in place one post in two hours, the average cost for all labor and material being $2 per post.

While this experiment has not taken into consideration many of the conditions set forth in the Case system of groynes, the results, up to the present time, have been entirely satisfactory, and the speaker is of the opinion that this inexpensive form of shore protection will be of great value in the protection and building up of exposed shore lines where the prohibitive cost of masonry and stone construction has prevented necessary improvements.

F. Collingwood, M. Am. Soc. C. E. (by letter.)—For some time the writer has been observing the effect of the use of groynes along the coast of New Jersey. In that locality they are always called jetties. As is well known, the ocean shoals very gradually, so that pound-nets are set nearly a mile from shore, and the large waves in a violent storm break about 1 000 ft. out. With the ocean comparatively quiet, the sand is heaped up along the immediate front; but the travel of the waves caused by a northeast or southeast storm cuts down the sand and makes a very long flat slope with a descent of only 4 or 5 ft. per 100 ft. Mr. Collingwood.

Before the regimen of the shore was disturbed by piers, bulkheads or groynes, this cutting and filling nearly balanced, so that the bluffs retreated but slowly. The building of various obstructions, jetties, etc., seems to have caused a deflection of the waves and currents, and

Mr. Collingwood. has also caused cutting at a rapid rate where the shore is unprotected. Those who visited the steamer *New York*, when stranded at Long Branch, saw a marked example of this.

The same is true at Avon, where, within a few years, the bluff has been cut back at least 25 ft., and the cut now imperils the ocean driveway.

All sorts and styles of protection have been adopted. The earlier attempts, at Long Branch and vicinity, were by bulkheads. These have failed invariably. A wave can be "tired out," but the power of its sweep against a vertical face is tremendous.

It will always be found that eventually a slope will be assumed by the sand, such that a wave will run up, lose its inertia by friction and the lifting of the wave, and come to rest, returning with diminished velocity and less capacity for mischief.

A dyke of fine, loamy sand, built out into the James River for the first Newport News dry-dock, was at first cut away rapidly by the waves, which had a sweep of 5 miles; but, after reaching a slope of 1 to 6 and greater, from high water down, the cutting ceased entirely.

The scheme of protection now mostly used on the Jersey Coast is that of groynes; but, as a whole, they are not constructed scientifically. One error, causing the expenditure of a considerable sum at Ocean Grove, and repeated again at Avon last summer, is the neglect to tie or secure properly the land end to the bluff. Although the writer called attention to the matter at Avon, no change was made, and to-day there is a cut landward of some 20 ft. beyond the groyne and around its inner end.

Another fault is making the groyne too high, as a whole. This results in a piling up of sand on one side (the side from which the wind may come), and a cutting on the lee side by the water pouring over the groyne. This upholds the claims made in Mr. Allanson-Winn's paper.

A third fault is insufficient length seaward. It is evident that the length should be such that the top of the groynes should be at about low water, and the slope about the same as the flattest slope assumed naturally by the sand when acted upon by the waves.

Of course, at the inner end, this slope must be increased, hence the whole discussion leads to the form adopted in the paper.

When reasonable methods are pursued the result is as may be seen at various points along this coast; the groynes, to a great extent, will be buried in the sand, and the bluff at the inner end fully protected. A length of about 150 to 180 ft. seems to be desirable in this locality, where the tidal rise is nearly 5 ft.

As to distance apart, the practice seems to vary. Manifestly, it must be such that no travel of the waves along the bluff will be possible. This would probably vary somewhat with the direction taken

by the prevailing winds. The distance adopted on the Jersey Coast, in many cases, seems to be too great; the same as the length of the groynes would no doubt be safe. Mr. Collingwood.

Considerable sums have been wasted by the unscientific treatment heretofore prevailing; and, undoubtedly, the field is one where good engineering would pay.

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PAPERS AND DISCUSSIONS.

THE MAINTENANCE OF ASPHALT STREETS.

Discussion.*

By Messrs. W. Boardman Reed and James N. Hazlehurst.

Mr. Reed. W. Boardman Reed, M. Am. Soc. C. E.—The speaker is not an expert on asphalt pavement, but has had considerable experience in the maintenance of such pavements beside street-railway tracks. In New York City, for several years past, it has been the practice to use what is known as the "Trilby" rail, having an inside flange, about $2\frac{1}{2}$ ins. wide, at the same height as the head, and to lay asphalt up against both sides of this rail. Where the rail is perfectly rigid, pavement of this character will last fairly well on streets with little traffic; but, where the traffic is heavy, there is an inclination for truckmen to follow the rail, and, dropping off it from time to time, wear ruts beside it.

On track which is not perfectly rigid it is almost impossible to maintain asphalt pavement next the rail in safe condition, and where this has been attempted it has been found to be very expensive to maintain it even in passable condition. On one of the street-railway lines in charge of the speaker the cost of the maintenance of asphalt between the rails only has been $4 500 per year per mile of single track, or about 52 cents per square yard. Toothing stones have been laid next to the rail, and a cast-iron strip has been used with considerable success for this purpose, with the idea of allowing the rail to vibrate against either the toothing stone or the iron strip without injuring the asphalt or the foundation upon which it is laid.

* Continued from October, 1902, *Proceedings*. See May, 1902, *Proceedings*, for paper on this subject by James N. Hazlehurst, M. Am. Soc C. E.

Much of the difficulty in the maintenance of asphalt on streets Mr. Reed. comes from the frequent tearing up of the street for repairs to substructures. There is no doubt that asphalt pavement can be laid so as to last many years with very little repair, if a proper foundation is put in and if that foundation is not disturbed. This is especially noticeable on Fifth Avenue in New York City, but, even there, where excavations have been made, bad settlements of the pavement have occurred shortly after it has been restored.

One point in the matter of maintenance the author has not touched. A company laying asphalt under guaranty practically has control of the street during the existence of the guaranty, and would be able to interfere more or less with any improvements, even though they might be desired by the city authorities. Such a company is able to demand almost any price, from any corporation that makes such improvements, for the privilege of tearing up and restoring the pavement, if such improvements change the surface of the street in any manner. In one instance, in New York City, where the pavement had been laid under a five-year guaranty, there was in the street a single street-railway track, constructed and operated for horse-cars. It was considered desirable, not only by the street-railway company, but by the city authorities, to change the location of the existing track and put in two tracks, making them according to the standard slotted construction of New York City, instead of the original horse-car construction. The asphalt company held that the laying of the second track and the change in the style of construction invalidated their guaranty contract, and the railway company was obliged to pay, and, rather than have litigation, did pay, a considerable sum to the asphalt company for the privilege of complying with the desires of the city authorities.

In the speaker's opinion, the exorbitant prices bid in the past for the laying and maintaining of asphalt, with the privilege of charging any corporation that may be obliged to disturb the pavement the contract price for its restoration, are unjust. Quite recently, it was necessary to make repairs to a street-railway track on a street where pavement had been laid, under a fifteen-year guaranty, at $4.86 per square yard. The guaranty would expire in 1908. The asphalt company, according to contract with the city, had the right to charge the full contract price for the restoration of this asphalt; whereas, under the present prices, the work could be done for less than $2 per square yard.

With regard to laying and maintaining asphalt beside the rail; in the year 1900, a surface track was laid on 34th Street, New York City, with a 9-in. girder-rail supported by a heavy concrete beam. This rail was perfectly rigid, there being no vibration, even though very heavy cars were operated over it. Special care was taken in the laying of the asphalt, yet it was not more than six or eight months before ruts appeared beside the rail, and it was necessary to make repairs.

Mr. Reed. Asphalt wears out rapidly at any point where it adjoins a harder material, as for instance, at the manholes of sewers, at water-gate boxes, etc., owing to the pounding of vehicles dropping from the hard to the softer surface.

Mr. Hazlehurst. J. N. HAZLEHURST, M. Am. Soc. C. E. (by letter).—In exercising his privilege of closing this discussion and of replying to criticism made by participating members, while disclaiming any intention of being captious or hypercritical, the writer is somewhat uncertain of his position and attitude on account of the considerable amount of irrelevant matter interjected by participants. Thus, one of these gentlemen objects to laying asphalt strips upon old block pavement for the use of bicyclists; another seeks information as to the cause of the rolling and cracking of asphalt pavements; while, of the two members who attempt to discuss the paper seriously, the remarks of one, if not entirely irrelevant, are, at least, full of generalities, as, for instance, the necessity for and character of the bond intended to secure the maintenance clause of such a contract; the possible increase of price due to the subsequent care of the pavement but concealed in the original proposal; a reiteration of the principle (stated by the writer) of the shadowy and narrow division line between maintenance and guaranty clauses; a recitation of the well-established fact that, to preserve the integrity of a contract for maintenance, due care must be taken by the city that acts of omission or of commission do not release the principal or relieve the surety; followed by a statement of the experience of New York City in having to pay an exorbitant charge for repair work which, although included, was overlooked in the consideration of the original contract; and finally, as an original proposition, suggesting that the contractor be allowed to follow his own judgment as to mixtures and measures if it is expected to hold him to specific and definite results.

This general treatment of the subject, while interesting, brings out out only one or two new points, and to these the writer desires to reply briefly. According to Mr. Whinery:

"There is one important feature of these long-time guaranties that seems not to have been brought before, or considered by, the Courts at all; that is, that in nearly every city the terms of contracts for paving, including the guaranty requirements, are general, and are made to apply to all streets alike. No allowance is made with respect to different streets for different conditions of use," etc.

While it is admitted that the character of the traffic upon the streets possibly included under such a maintenance clause is variable, the conditions are possibly not more eccentric than those surrounding the same streets, let at the same time, and under the same specifications for constructive work, and upon which the unit price bid is the same, in both cases, it being entirely possible for the contractor to balance his estimate of cost so as to reach a fair average price both for construction or for maintenance.

Again, Mr. Whinery declares that: Mr. Hazlehurst.

"In the early history of asphalt pavement, when its merits were questioned and distrusted, when the properties of the material used were not well understood and the methods of constructing it were not familiar to engineers, it cannot be doubted that the requirement of some guaranty of results was not only justified, but was required by ordinary business prudence. But that time has now passed," etc.

While it is a fact beyond contention that certain well-known brands of asphalt are thoroughly understood and may be fully relied upon under given conditions, to discriminate in their favor produces a limited competition, to avoid which and yet to safeguard municipal authorities, it is proposed by the writer to rely more fully upon the guaranty of the contractor for successful and permanent work.

The writer can hardly believe that even as experienced an engineer as Mr. Whinery is conceded to be would be willing to rely entirely upon the determination by himself and his chemist of the particular merits of an untried asphaltic material, such as the bituminous rock or liquid product of California, Texas or Utah. If he contends that such unknown material should be barred, as has long been the habit of many of our larger cities, there is little encouragement offered to honest competition against the larger companies, and he would endorse and perpetuate monopoly, collusion and the whole train of ills due to restricted competition and class legislation.

Furthermore, notwithstanding Mr. Whinery's assertion, that "Our cities can safely rely upon their engineers to prepare adequate specifications, and to enforce them so as to secure work of the highest standard of excellence," the tendency is distinctly toward contracts with a longer maintenance or guaranty clause, and where, formerly, five years was considered a sufficient term of guaranty, ten years is now more common, and fifteen years is not an unusual requirement in this country, while the standard term for maintenance in German cities is nineteen years!

Mr. Nelson P. Lewis, in his consideration of the subject, calls into question the fairness of taking the recorded cost of maintenance for the asphalt pavements of the City of Washington as a representative and equitable basis of cost, but without pausing to justify the correctness and fairness of the reference figures, the writer's contention is for the principle or system of fixing a stipulated sum as the maximum price for the maintenance of the pavement, not to be paid as a bonus, but only as earned; and contends that such an arrangement furnishes a fair working hypothesis, although admitting that the contractor will have to make a "guess" as to the actual cost of such maintenance. Is there ever any certainty in the bid of a contractor for the execution of a contract? Then, why should it be less legitimate for the contractor to "guess" at the cost of maintaining any piece of work than for him to "guess" at its first cost?

Mr. Hazlehurst.

Referring to Mr. Lewis' recommendation that:

"After the expiration of the original contract covering not more than five years, subsequent contracts for from one to five years be made for maintaining the pavements, which contracts should provide that the contractor be paid for the material actually used, and which would be placed where directed."

The advantage of this method of securing necessary material for repairs would be, as suggested by Mr. Lewis, the element of saving under such a contract, in the repairs to streets, which, from their age or traffic, have been reduced in thickness. This method of arriving at an equitable measurement of the value of the required materials for repair is novel and undoubtedly possesses good points, but the annual wear and tear of the street surface, and its consequent loss in thickness under traffic may be discounted by the contractor and equated for in the original proposal for construction.

MEMOIRS OF DECEASED MEMBERS.

NOTE.—Memoirs will be reproduced in the Volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Secretary prior to the final publication.

LORENZO RUSSELL CLAPP, M. Am. Soc. C. E.*

DIED AUGUST 13TH, 1902.

Lorenzo Russell Clapp was born in Quincy, Massachusetts, on April 25th, 1843. He was descended from Thomas Clapp, who settled in Scituate in 1640, and on his maternal side, was great-grandson of Captain Jonathan Clark.

In 1850 Mr. Clapp's family moved from Quincy to Dorchester. He was graduated from the Dorchester High School in 1860, and in 1861 he enlisted in the United States Navy, where he served until the close of the Civil War. He studied civil engineering under General Minot, later Chief Engineer of the City of Boston. At the same time he served a three-years' apprenticeship in the office of the late Thomas Doane, M. Am. Soc. C. E. His first experience in the field was with the Old Colony and Cape Cod Railway.

In 1869 he came to Brooklyn, New York, and received the appointment of Assistant Engineer in the Department of Public Works. He served in this department under the following Chief Engineers: The late Moses Lane, M. Am. Soc. C. E.; the late Julius W. Adams, Past-President, Am. Soc. C. E., and Robert Van Buren, M. Am. Soc. C. E. He was Resident Engineer in charge of building the Hempstead Storage Reservoir; he also had charge of several important improvements on the Brooklyn water-shed.

In 1882 he was placed in charge of the Brooklyn Relief Sewer system, and was Constructing Engineer for the great tunnel sewers in North Second Street and Greene Avenue, in that city.

Besides work for the City of Brooklyn, Mr. Clapp was associated for several years with the late Austin Corbin, in the Long Island Improvement Company's Fort Pond Bay surveys, Manhattan Beach improvements, etc.

Mr. Clapp was considered an expert in tunneling and sewer construction; as an engineer in construction he was well known to those of his profession, and he won the respect and confidence of all who were associated with him.

In 1894, after Mr. Van Buren left the Brooklyn Department of Public Works, he also resigned and entered the contracting business.

* Memoir prepared by Robert Van Buren, M. Am. Soc. C. E.

This work, however, was uncongenial to him, and worry over several bad contracts, doubtless, had much to do with his breaking down and sudden death.

Since 1870 Mr. Clapp's home has been at Hempstead, Long Island. While resident there, in charge of the Storage Reservoir, he married, in 1874, Miss Suzannah J. Smith, of Foster's Meadow. His wife and one son survive him.

Mr. Clapp was devoted to his profession, and found, in its demand for accuracy and truth, an atmosphere well suited to the conscientiousness and clear, cool judgment that was his natural heritage. He became a Member of the American Society of Civil Engineers on February 1st, 1888.

ARTHUR STANLEY HOBBY, M. Am. Soc. C. E.*

DIED MAY 28TH, 1902.

Arthur Stanley Hobby was born in Manchester, England, on March 15th, 1836, being the eldest of three sons of Benjamin Hobby, a manufacturer of wooden silk-working machinery. He was educated in St. Saviours School, at Manchester, and was articled as a "pupil teacher" in that school as the result of competitive examinations, according to the methods in vogue at that time. Upon finishing his term in 1854, he entered the employ of a large shipping firm, Jackson and Company, of Manchester, where he remained for three years. Not finding commercial business congenial, he articled himself in 1857 for a term of seven years to Mr. John Shaw, Civil and Mining Engineer, of Derby, England, who, in addition to a large general practice, was engineer to large coal-mining interests in that district. Due to his sound judgment in engineering matters, Mr. Hobby soon became an important assistant to his employer, and was entrusted with many problems of importance. In 1864 he was engaged by Mr. J. H. Arkwright to make surveys of an extensive estate in Herefordshire, upon the completion of which he established a private practice at Kingston, where he also built and operated on his own account a steam brickyard, using the patent Hoffman kilns. It is believed that this was quite a departure from the regular methods of brick manufacture at that time, but it was quite successful. While at Kingston Mr. Hobby married Miss Maria Elizabeth Bishop.

In 1871, due to the failing health of his wife, he moved to Virginia and tried farming, but soon drifted into his professional work again, holding positions on various projects in Virginia and Kentucky, among

* Memoir prepared by his son, Arthur Stanley Hobby, Jr., Assoc. M. Am. Soc. C. E.

them being the Chesapeake and Ohio Railroad, the proposed Big Sandy Railroad, and various surveys of coal properties in Kentucky and Ohio.

In 1876 he settled in Cincinnati, Ohio, and became City Sewerage Engineer, under Latham Anderson, M. Am. Soc. C. E., City Engineer, both having been elected to office on the great reform wave which swept the city that year. Until that time Cincinnati had been drained by a very imperfect system of "combined" sewers, and Mr. Hobby introduced what is now known as the "separate" system, but was then known throughout that locality as the "Hobby" system. It will thus be seen that Mr. Hobby was one of the original workers along that line, and Cincinnati was one of the first cities in the country to adopt that system, notwithstanding the fact that the public offered great opposition and ridiculed the system severely. The idea that a city of the size of Cincinnati could be drained by small pipe sewers was preposterous! He, however, had the courage of his convictions, and his arguments were so sound that he won the day, and his plans were adopted. During the four years that he remained in office a great deal was done to put the city on a proper sanitary basis, and the plans and regulations prepared by him are still followed, with but little if any variation.

About the year 1880 another political turnover put both Colonel Anderson and Mr. Hobby out of office, and the firm of Anderson and Hobby was formed, which enjoyed a very large practice.

In 1885, or the early part of 1886, owing to the failing health of Mr. Anderson, the firm was dissolved, and Mr. Hobby continued the business in his own name. Among the most notable of Mr. Hobby's works during that period were the design and construction of the plant and town of Ivorydale, for the Proctor and Gamble Company, the design and construction of the plant and town of Addyston for the Addyston Pipe and Steel Company, these plants at the time being the largest of their kind in the United States. He also introduced his sewer system into a number of towns and villages of Southwestern Ohio. His advice on sanitary matters was sought by many towns throughout the Central West. He was for many years Engineer to the Villages of Clifton and Avondale, Ohio, now a part of Cincinnati, and throughout that section of the country many important works stand as monuments to his sound judgment and skill.

In 1882, at Woodsdale, a small town near Hamilton, Ohio, he constructed a wooden dam across the Big Miami River, where the banks and bed of the stream were composed of shifting sands, and where three dams had already failed. The purpose of the dam was to maintain a valuable water-power right. The dam was built during the winter, under great difficulties, and was inundated by a heavy freshet when about half built, but it is still there.

In 1898 he gave up his practice in Cincinnati, and went for a short time to Philadelphia and then to Southern California. He died in Los Angeles on May 28th, 1902, after a stroke of paralysis followed by a lingering attack of typhoid fever, and leaves a widow, three daughters and a son.

Mr. Hobby was elected a Member of the American Society of Civil Engineers on June 6th, 1894.

GEORGE WASHINGTON HOWELL,* M. Am. Soc. C. E.

DIED FEBRUARY 15TH, 1901.

George Washington Howell was born at the Howell Homestead, Littleton, Morris County, New Jersey, on December 21st, 1835, his father being the Honorable Edward Howell, and his mother Mary Lee, both descendants of old colonial families. When a lad of sixteen, young Howell accepted the position of teacher in a small country school near his home, and four years later he entered the New Jersey State Normal School, where, after being graduated, he remained as instructor in mathematics and languages for several years. Finding that his talents lay in the engineering line, however, he severed his connection with the Normal School, and studied civil engineering.

For some time he was associated with the late Professor George H. Cook, State Geologist of New Jersey, preparing the topographical maps and geological reports of the State, and it may be interesting to know that he prepared and made the first four sheets of the New Jersey State Topographical Survey.

Mr. Howell was at one time Constructing Engineer of the New Jersey West Line Railroad, and of the Western New York and Pennsylvania Railroad, being also connected with the Delaware, Lackawanna and Western Railroad at the Hoboken Terminal, the Boonton Branch and the Binghamton Extension.

Mr. Howell was Engineer for the Morris Aqueduct for Morristown, New Jersey, and designed many of the reservoirs. He was also Engineer for the State Hospital at Morris Plains, for which he designed the water-works and sewage disposal systems, as well as the landscape work. He was Engineer for Morris County and Morristown, New Jersey, for many years.

In later years he made a special study of drainage, water supplies, etc., and was appointed a member of the original Commission for the Drainage of Flow Lands along the Passaic River, serving as Secretary and Engineer until his death. In 1879, in conjunction with J. James

* Memoir prepared by James Owen, M. Am. Soc. C. E., and from a Memoir published by the New Jersey State Sanitary Association.

R. Croes, M. Am. Soc. C. E., Mr. Howell made an exhaustive report on an investigation of the possible source of water supply for Newark, New Jersey, and this investigation brought him into many of the water suits of recent years. He was also connected with the East Jersey Water Company in investigations for water supply and installing the water-works of Montclair, New Jersey.

In addition to his engineering work, which, in later years, was principally as expert and consulting engineer on water-works, sewage disposal, bridges, etc., Mr. Howell was connected with many organizations not bearing directly upon his profession. He was a member of the State Board of Education, of the New Jersey State Sanitary Association, of the Board of Directors of the Morristown Memorial Hospital, for which he was also Secretary, of the Washington Association of New Jersey, and of the Sons of the American Revolution.

In all this busy life, however, Mr. Howell still found time for his church work, and was President of the Board of Trustees and Deacon for life of the Morristown Baptist Church. He was also Recording Secretary of the Morris County Sabbath School Association and Secretary of the North Jersey Baptist Association. He served also as Treasurer of the Young Men's Christian Association.

From early manhood Mr. Howell had a keen love for reading, and spent much time in his library, where he also wrote many contributions to the press, especially upon historical matters, as he was well versed in State and local genealogical matters of historical interest.

Truly revered and loved as Mr. Howell was by all his many associates on the boards and in the associations of which he was a member, yet it remained for those who knew him in his private life to value him at his true and sterling worth. He was married on December 31st, 1862, to Rachel M. Cornish, of Gillette, New Jersey, and had five children, all of whom survive him.

Throughout his entire life Mr. Howell was the model of a Christian gentleman, thorough and conscientious in his work, honorable in business dealings, and singularly courteous and winning in his manners toward all with whom he came in contact.

Mr. Howell was elected a Member of the American Society of Civil Engineers on May 2d, 1888.

ARTHUR TOWNE THOMAS, M. Am. Soc. C. E.*

DIED OCTOBER 10TH, 1900.

Arthur Towne Thomas was born in the Town of Stowe, Vermont, on August 30th, 1862. His parents were Abijah Towne and Clarissa Slayton Thomas, and he was the youngest of five children, of whom three were boys. His education was obtained at the district school, with one year in the high school in his native town. He left school at the age of 17, and went to Minnesota in 1880 to begin work as Chainman on railroad surveys. In March, 1881, he was Transitman on the St. Paul, Minneapolis and Manitoba Railway, with which road he remained until January, 1883, being engaged on surveys and as Assistant Engineer in charge of construction.

From February, 1884, until March, 1888, he was connected with the Minnesota and Northwestern Railway (now the Chicago and Great Western). Beginning as Transitman, he was advanced to the position of Division Engineer, having charge of the construction of numerous high trestles and iron bridges. From March, 1888, to March, 1889, he was in charge of railway terminals and dock works at Superior, Wisconsin. He was then appointed first City Engineer of Superior, which office he held until March, 1900, with the exception of four years, during which he was engaged as Chief Engineer of the Superior Water, Light and Power Company and the West Duluth Light and Water Company, in designing and constructing water-works, gas and electric light stations. Part of this time was also devoted to the study of mining engineering and its application to exploration work in the iron and gold fields of Northern Minnesota and Ontario.

In October, 1900, while he was Superintendent of the Chippewa Copper Mine, at Brule, Wisconsin, he went out prospecting, and, not returning when expected, search was made and his body found in the woods. Upon investigation, it was found that he had been shot, the bullet piercing the jugular vein and spinal cord. By means of the peculiar bullet, a deer hunter was discovered who acknowledged that he had shot Mr. Thomas accidentally and then abandoned the body heartlessly.

The conscientious attention which Mr. Thomas gave to his work, and his faithful performance of it, together with his earnest desire to accomplish the best results for those whose interests were intrusted to him, gained the respect and friendship of all who knew him.

Mr. Thomas was elected a Member of the American Society of Civil Engineers on June 6th, 1894.

* Memoir prepared by George L. Wilson, M. Am. Soc. C. E.

KENNETH OAKE PLUMMER REINHOLDT, Assoc. M. Am. Soc. C. E.

Died February 6th, 1902.

Kenneth Oake Plummer Reinholdt was born in New Castle, Pennsylvania, on September 27th, 1866, and was the only son of the late Dr. J. B. Reinholdt, of that city. His earlier education was received in the public schools of New Castle. Later, he attended Allegheny College, at Meadville, Pennsylvania, and from there he went to Rensselaer Polytechnic Institute, at Troy, New York, from which he was graduated in June, 1890.

In the following year he was employed in the laboratory of the steel plant of the Phœnix Iron Company in Phœnixville, Pennsylvania. In December, 1891, he accepted the position of Inspector of lumber and piles with the Engineer of Construction of the Central Railroad of New Jersey, and in March, 1892, he was given charge of the construction of the terminal pier of the Navesink Railroad, at Atlantic Highlands, where he located and completed the station buildings for the main dock and, also, all necessary sheds, platforms, trestles, etc.

He continued in the employ of the Central Railroad of New Jersey, as assistant to the Engineer of Construction, until September, 1895. During that time he made surveys and plans, and had charge of the elimination of grade crossings at Elizabeth, Cranford and Bayonne. He also located bridges at Freehold and Lorillard, New Jersey.

In September, 1895, he opened an office in New Castle, Pennsylvania, for private engineering practice, doing general city and country work. He designed a number of large buildings, and was recognized as a young man of talent in more lines than one. He had considerable ability as an artist, and had a fine collection of drawings.

In June, 1896, he accepted a position in Pittsburg, Pennsylvania, as draftsman with the Butler and Pittsburg Railroad. and, later, was made Assistant Engineer of the Bessemer and Lake Erie Railroad, a position which he held at the time of his death.

During the summer of 1901, while in Greenville, Pennsylvania, superintending the building of a new branch of the railroad, he contracted a severe cold, which developed into tuberculosis. His health failed rapidly, and in the early winter he and his wife left for Phœnix, Arizona, in hope that a change of climate would restore his health. It was too late, however, to overcome the disease which was undermining his constitution, and his strength waned day by day until the end.

Mr. Reinholdt was characterized by great faithfulness to all details of his duties, and was devoted to his profession. There was every indication of a brilliant career for him, and his sudden death caused poignant sorrow to his many friends. He was a young man of upright

character, and possessed a manner so kind that he was always surrounded by a circle of admiring friends. In June, 1900, Mr. Reinholdt was married to Miss Belle Paine, of Youngstown, Ohio, and she and an infant daughter survive to mourn their irreparable loss.

Mr. Reinholdt was elected a Junior of the American Society of Civil Engineers on February 6th, 1894, and an Associate Member on October 7th, 1896.

PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS.

(INSTITUTED 1852.)

VOL. XXVIII. No. 10.

DECEMBER, 1902.

Edited by the Secretary, under the direction of the Committee on Publications.

CONTENTS.

NEW YORK 1902.

American Society of Civil Engineers.

OFFICERS FOR 1902.

President, ROBERT MOORE.

Vice-Presidents.

Term expires January, 1903:	*Term expires January, 1904:*
HENRY S. HAINES,	CHARLES C. SCHNEIDER,
GEORGE H. BENZENBERG,	JOHN R. FREEMAN.

Secretary, CHARLES WARREN HUNT.

Treasurer, JOSEPH M. KNAP.

Directors.

Term expires January, 1903:	*Term expires January, 1904:*	*Term expires January, 1905:*
JOHN F. O'ROURKE,	JOSIAH A. BRIGGS,	RICHARD S. BUCK,
HENRY B. SEAMAN,	GEORGE F. SWAIN,	GEORGE H. PEGRAM,
THOMAS H. JOHNSON,	EMIL KUICHLING,	WILLIAM J. WILGUS,
JOSEPH RAMSEY, JR.,	MORDECAI T. ENDICOTT,	WILLIAM JACKSON,
HENRY B. RICHARDSON,	EDWARD C. CARTER,	EDMUND F. VAN HO ESEN
WILLIAM H. KENNEDY.	FRANK C. OSBORN.	JAMES L. FRAZIER.

Assistant Secretary, T. J. McMINN.

Standing Committees.

THE PRESIDENT OF THE SOCIETY IS *ex-officio* MEMBER OF ALL COMMITTEES.

On Finance:	*On Publications:*	*On Library:*
JOSIAH A. BRIGGS,	JOHN F. O'ROURKE,	HENRY S. HAINES,
G. H. BENZENBERG,	GEORGE H. PEGRAM,	CHARLES C. SCHNEIDER,
GEORGE F. SWAIN,	THOMAS H. JOHNSON,	MORDECAI T. ENDICOTT,
RICHARD S. BUCK,	JOSEPH RAMSEY, JR.,	EMIL KUICHLING,
WILLIAM J. WILGUS.	FRANK C. OSBORN.	CHARLES WARREN HUNT.

Special Committees.

ON UNIFORM TESTS OF CEMENT:—George S. Webster, George F. Swain, Alfred Noble, W. B. W. Howe, Louis C. Sabin, S. B. Newberry, Clifford Richardson, Richard L. Humphrey, F. H. Lewis.

ON RAIL SECTIONS:—G. Bouscaren, C. W. Buchholz, S. M. Felton, Robert W. Hunt, John D. Isaacs, Richard Montfort, H. G. Prout, Joseph T. Richards, Percival Roberts, Jr., George E. Thackray, Edmund K. Turner, William R. Webster.

The House of the Society is open from 9 A.M. to 10 P.M. every day, except Sundays Fourth of July, Thanksgiving Day and Christmas Day.

HOUSE OF THE SOCIETY—220 WEST FIFTY-SEVENTH STREET, NEW YORK.

TELEPHONE NUMBER, - - - - 588 Columbus.
CABLE ADDRESS, - - - - - "Ceas, New York."

Vol. XXVIII. DECEMBER, 1902. No. 10.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PROCEEDINGS.

This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

SOCIETY AFFAIRS.

CONTENTS:

MINUTES OF MEETINGS.

OF THE SOCIETY.

December 3d, 1902.—The meeting was called to order at 8.45 P. M., Vice-President Haines in the chair; Chas. Warren Hunt, Secretary; and present, also, 69 members and 13 guests.

The minutes of the meetings of November 5th and 19th, 1902, were approved as printed in *Proceedings* for November, 1902.

A paper, entitled "Virtual Grades for Freight Trains," by A. C. Dennis, M. Am. Soc. C. E., was presented by the Secretary, who also read a communication on the subject from B. S. Randolph, M. Am. Soc. C. E. The paper was discussed orally by Messrs. S. Maximoff, F. H. Hebblethwaite and the author.

Ballots for membership were canvassed, and the following candidates were elected:

As Members.

Edward Chester Barnard, Washington, D. C.
Maurice Wurtz Cooley, Boston, Mass.
Ralph Lee Crump, Kansas City, Mo.
George Robert Ferguson, New York City.
Martin Hughes Gerry, Jr., Helena, Mont.
William Chauncey Hawley, Wilkinsburg, Pa.
Edmund Taylor Perkins, Washington, D. C.

As Associate Members.

William Henry Adey, Cohoes, N. Y.
Frederick Auryansen, Brooklyn, N. Y.
George Morgan Bacon, Salt Lake City, Utah.
Charles Edwin Bright, Tuscaloosa, Ala.
Frank Chauncey French, Davenport, Okla. T.
Lester Robinson Gifford, Johnstown, Pa.
Frank Arnold Hastings, Pittsburg, Pa.
William Nelson Hazen, Baltimore, Md.
Arthur Hirst, Pencoyd, Pa.
Clarence McKenzie Lewis, New York City.
Thomas Alexander Ross, Shanghai, China.
Edward De Voe Tompkins, Brooklyn, N. Y.
Edward Dana Wickes, New York City.

The Secretary announced the election of the following candidates by the Board of Direction, on December 2d, 1902:

As Associate.

Stedman Bent, Overbrook, Pa.

As Juniors.

Wallace Edward Belcher, Pencoyd, Pa.
Francis Rigdon Berry, Joplin, Mo.
Edward Betts Brisley, New York City.
Roscoe Bradbury Jackson, Ann Arbor, Mich.
Francis Joseph Lynch, New York City.
Royal John Mansfield, Pittsburg, Pa.
Neal Albert Melick, New York City.
Carl Julius Schumann, Troy, N. Y.

The Secretary announced the death of the following members:

ROBERT ATTWELL WAY, elected Member June 7th, 1894; died in April, 1901.

CHARLES FLETCHER HILLMAN, elected Member July 5th, 1876; died June 14th, 1902.

JOSEPH MILLER WILSON, elected Member April 2d, 1873; died November 24th, 1902.

HENRY MITCHELL, elected Member January 7th, 1880; died December 1st, 1902.

The Secretary announced that the Annual Convention of 1903 would be held at Asheville, N. C., during the week beginning June 8th, 1903.

Adjourned.

December 17th, 1902.—The meeting was called to order at 8.45 P.M., Emil Kuichling, Director, Am. Soc. C. E., in the chair; Chas. Warren Hunt, Secretary; and present, also, 107 members and 17 visitors.

An informal discussion, on "The Sanitary Disposal of Municipal Refuse," was opened by Rudolph Hering, M. Am. Soc. C. E. The subject was discussed by Messrs. John McG. Woodbury, H. de B. Parsons and W. F. Morse, and illustrated with lantern slides.

The further discussion of the subject was postponed until the meeting of January 7th, 1903.

The Secretary announced that he had received written communications on the subject from Messrs. Charles H. Haswell and Elmer W. Firth, but that owing to the postponement of the discussion, they would be presented at the next meeting.

The Secretary announced the death of Charles Edward Henry Campbell, elected Member October 3d, 1883; died December 6th, 1902.

Adjourned.

OF THE BOARD OF DIRECTION.

(Abstract.)

December 2d, 1902.—Vice-President Haines in the chair; Chas. Warren Hunt, Secretary; and present, also, Messrs. Briggs, Croes, Knap, Kuichling, Osborn, Pegram, Schneider, Seaman and Swain.

Four members were named as Members of the Board of Award of the John Fritz Medal.*

Upon the recommendation of a Special Committee appointed for the purpose, it was decided that the next Annual Convention of the Society be held at Asheville, N. C., during the week beginning June 8th, 1903.

A Committee of Arrangements for the Annual Meeting was appointed.

Applications for membership were considered, and other routine business transacted.

One candidate for Associate and eight for Junior were elected.†

Adjourned.

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* See page 346.
† See page 342.

ANNOUNCEMENTS.

The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

MEETINGS.

Wednesday, January 7th, 1903.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and the discussion on the topic "The Sanitary Disposal of Municipal Refuse," which took place at the meeting of December 17th, 1902, will be continued.

ANNUAL MEETING.

The Fiftieth Annual Meeting will be held at the Society House, January 21st and 22d, 1903. The Business Meeting will be called to order at 10 o'clock on Wednesday morning. The annual reports will be presented, officers for the ensuing year elected, members of the Nominating Committee appointed, a proposed amendment to the Constitution considered, and other business transacted.

Arrangements for the excursions and entertainments have been placed in the hands of the following committee, and will be announced later:

ALFRED CRAVEN,
W. F. WHITTEMORE,
CHAS. WARREN HUNT.

ANNUAL CONVENTION OF 1903.

The Thirty-fifth Annual Convention of the Society will be held at Asheville, N. C., during the week beginning June 8th, 1903.

NOMINATING COMMITTEE.

The Constitution provides that, at the Annual Meeting of each year, seven Corporate Members, not officers of the Society, one from each of the geographical districts into which the Society is divided for this purpose, shall be appointed by the meeting to serve for two years.

The usual blank request for suggestions as to representatives of each district, for presentation to the meeting, has been mailed to Corporate Members.

LOUISIANA PURCHASE EXPOSITION.

The Board of Direction, at its meeting on November 4th, 1902, authorized the appointment of a committee to take up the question of an exhibit, in the name of the Society, at the World's Fair, St. Louis, 1904; and also to take such action as may be deemed necessary in interesting members of the Society in general in an engineering exhibit.

The committee appointed for this purpose is as follows:

Robert Moore,
John F. Wallace,
E. Kuichling,
Mordecai T. Endicott,
Edward C. Carter,
William Jackson,
James L. Frazier.

THE JOHN FRITZ MEDAL.

The Board of Direction, in accordance with the terms of Clause 6 of the following rules for the award of this medal, has named the following members of the Society as members of the Board of Award:

To serve one year,		J. James R. Croes.
" "	two years,	Robert Moore.
" "	three "	Alfred Noble.
" "	four "	Chas. Warren Hunt.

Origin and Rules for the Award of the John Fritz Medal.

(1) The John Fritz Medal was established by the professional associates and friends of John Fritz, of Bethlehem, Pa., U. S. A., August 21st, 1902, his eightieth birthday, to perpetuate the memory of his achievements in industrial progress.

(2) The medal shall be awarded for notable scientific or industrial achievement. There shall be no restriction on account of nationality or sex.

(3) The medal shall be of gold (of..........ounces weight and ......fineness), and shall be accompanied by an engraved certificate, which shall recite the origin of the medal, and the specific achievement for which the award is made. Such certificate shall be signed by the Chairman and the Secretary of the Board of Award.

(4) The medal may be awarded annually, but not oftener.

(5) No award of the medal shall be made to any one whose eligibility to the distinction has not been under consideration by the Board of Award for at least one year.

(6) Awards shall be made by a Board of sixteen, appointed or chosen, in equal numbers, from the membership of the four National Societies: The American Society of Civil Engineers, The American Institute of Mining Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. The governing bodies of each of these societies shall be requested to appoint from its membership one representative who shall hold office for one year, one for two years, one for three years, and one for four years; and each succeeding year to appoint one member to serve for four years.

(7) In case of failure of any of the National Societies to make the original appointments as requested, the selection of representatives from its membership shall be made by those appointed from the other societies, and should any future vacancy occur by reason of the failure of any of the said societies to act, or otherwise, such vacancy shall be filled by the Board of Award, from the membership of the Society so failing.

(8) Should one or more of the four National Societies go out of existence, its representation on the Board shall cease and terminate, and future awards shall be made by the representatives of the remaining societies.

(9) The vote of the Board of Award shall be by letter-ballot, which shall be canvassed not less than thirty days subsequent to its issue, and the affirmative votes of at least three-fourths of the Board shall be necessary for an award.

ACCESSIONS TO THE LIBRARY.

From November 12th to December 9th, 1902.

DONATIONS.*

THE SCIENCE OF MECHANICS.

A Critical and Historical Account of its Development. By Dr. Ernst Mach. Translated from the German by Thomas J. McCormack. Second Revised and Enlarged Edition. Cloth, 8 x 6 ins., 19 + 605 pp., illus. Chicago, The Open Court Publishing Company, 1902. $2.00.

The preface states that the present volume is not a treatise upon the application of the principles of mechanics. Its aim is to clear up ideas, expose the real significance of the matter, and get rid of metaphysical obscurities. The little mathematics it contains is merely secondary to this purpose. The text of the present edition, which contains the extensive additions made by the author to the latest German editions, has been thoroughly revised by the translator. All errors, either of substance or typography, so far as they have come to the translator's notice, have been removed, and in many cases the phraseology has been altered. The author's additions have been relegated to the appendix, first, because the numerous references in other works to the pages of the first edition thus hold good for the present edition also, and secondly, because with few exceptions the additions are either supplementary in character, or in answer to criticisms. The Contents are: The Development of the Principles of Statics; The Development of the Principles of Dynamics; The Extended Application of the Principles of Mechanics and the Deductive Development of the Science; The Formal Development of Mechanics; The Relation of Mechanics to other Departments of Knowledge. There is an index of twelve pages.

FOWLER'S MECHANICAL ENGINEER'S POCKET-BOOK FOR 1903.

Edited by William H. Fowler, M. Inst. C. E., M. I. Mech. E., M. Iron and Steel Inst. Leather, 6 x 4 ins., 441 pp., illus. Scientific Publishing Co., Manchester. 2 shillings 6 pence.

The preface states that in the present edition extensive additions and emendations have been made, with a view to keep it fully abreast with the times. Numerous new tables, calculated to help the engineer in his daily work, have been included, while substantial additions have been made in the section on steam boilers and engines, embodying the latest information available respecting recent developments in connection with superheating, oil-burning, water-tube boilers, etc. The gas engine section has also been thoroughly revised, and much original matter, with many tables, is here published for the first time. With a field so wide as mechanical engineering, with its continual discoveries and ever-growing experience, any reference book of this kind must, of necessity, be incomplete in some directions. The difficulty is to make a selection which will meet the daily requirements of the average engineer without being inconvenient or unwieldy. This is the object the author has kept in view, and he trusts, in some measure, has succeeded in fulfilling. There is an index of fifty-five pages.

GENERAL SPECIFICATIONS FOR FOUNDATIONS AND SUPERSTRUCTURES

Of Highway and Electric Railway Bridges. By Theodore Cooper. Paper, 9½ x 7 ins., 24 pp., 13 plates. The Engineering News Publishing Company, New York, 1902. $1.00. (Donated by the Author.)

The author states in the preface that he has herewith endeavored to illustrate the more common forms of superstructures and foundations suitable for highway bridges, and gives the required proportions for all ordinary cases, with instructions and specifications for their construction. The author excludes from consideration difficult foundations in deep water, or those requiring pneumatic or other special appliances, or works of such expense as would demand especial study of the conditions to determine the best or most economical solution; also city bridges and long-span bridges, where a higher and more elaborate class of substructure may be demanded and justified.

THE COAL AND METAL MINERS' POCKET-BOOK

Of Principles, Rules, Formulas, and Tables. Specially Compiled and Prepared for the Convenient Use of Mine Officials, Mining Engineers,

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* Unless otherwise specified, books in this list have been donated to the Library by the Publisher.

and Students Preparing Themselves for Certificates of Competency as Mine Inspectors or Mine Foremen. Seventh Edition: Revised and Enlarged, with Original Matter. Leather, 7 x 4 ins., 12 + 637 pp., illus. Scranton, Pa., International Textbook Company, 1902. $3.00. (Donated by *Mines and Minerals.*)

The preface states that the speedy exhaustion of the sixth edition has made this present edition necessary. In it a few typographical errors in the previous edition have been corrected, all departments have been carefully revised, improved, and brought up to date, and considerable new matter has been added. The glossary, which contains about 2 600 words, is a combination of all mining glossaries extant of which the compilers could hear. The Contents are: Weights and Measures; Applied Mechanics; Forms of Power; Mining. There is an index of seventeen pages.

CITY BENCH MARKS, HARTFORD, CONN.

Published by Frederick L. Ford, City Engineer, under the Directions of the Board of Street Commissioners. Leather, 7 x 3½ ins., 95 pp. Hartford, 1902. (Donated by Frederick L. Ford.)

The preface states that the benches contained in this book were established by the City Engineer during the years 1900 and 1901. The old and new systems should correspond approximately, both being referred to the same datum. If any errors between individual benches on the two systems exist, they are due to changes which have taken place in the structures upon which the old benches were established.

RAILWAY TRACK AND TRACK WORK.

By E. E. Russell Tratman, M. Am. Soc. C. E. Second Edition. Cloth, 9 x 6 ins., 4 + 471 + 9 pp., illus. New York, The Engineering News Publishing Co. $3.00. (Donated by the author.)

The present edition has been almost entirely rewritten and set up in new type. Since 1897, many changes and improvements have been made in materials and methods, while, with the general progress made in this department, new standards have been adopted, and these various improvements are represented in the revision. Not only has the book been thoroughly revised, but many new illustrations have been made, and additional chapters have been added dealing with signals, interlocking, and street-railway track. The tables of standard track construction in the appendix are also entirely new. A special feature of the book is that it includes not only the general principles underlying track work, and the systems of practice which are everywhere applicable, but also includes numerous individual details of material, appliances and work, and methods of practice, which vary on different railways and in different sections of the country. It has been the author's special aim to present drawings and details of materials and methods, representing varied and actual practice, and to show their good and bad features, as well as the reasons for their use. The chapter headings are: Introduction; Roadbed Construction; Ballast; Ties and Tie-Plates; Rails; Rail Fastenings and Rail-Joints; Switches, Frogs and Switchboards; Fences and Cattle-Guards; Bridge Floors and Grade Crossings; Track Signs; Tanks and Other Track Accessories; Sidings, Yards and Terminals; Track Tools and Supplies; Signals and Interlocking; Street Railway Track; Organization of Maintenance-of-Way Department; Track-laying and Ballasting; Drainage and Ditching; Track Work for Maintenance; Gage, Grades and Curves: Track Inspection and the Premium System; Switch Work and Turnouts; Bridge Work and Telegraph Work; Permanent Improvements and Work Trains; Handling and Cleaning Snow; Wrecking Trains and Operations; Records, Reports, and Accounts; Table of Standard Track Construction on 50 Railways; Table of Train Speeds and Distances Run. There is an index of nine pages.

STEREOTOMY.

By Arthur W. French, Assoc. M. Am. Soc. C. E., and Howard C. Ives, Jun. Am. Soc. C. E. Cloth, 9 x 6 ins., 7 + 115 pp , illus. New York, John Wiley & Sons, 1902. $2.50.

It is believed by the authors that, for some time, there has been a need for a textbook on stereotomy which should furnish, in addition to the exercises in projections now given by a number of works, practical examples of modern masonry structures, directions for the preparation of drawings which are made daily by engineers and architects, and more of the practical detail of building stone masonry. No claim is made for originality in the text, the aim of the authors having been to select matter from older works, to condense where possible, add explanations where it was deemed necessary, and to bring together matter which has been found scattered through many works. The chapter headings are: Definitions and Classifications; Stone-Cutting; Plane-Sided Structures; Structures Containing Developable Surfaces; The Oblique or Skew Arch; Other Problems. There is an index of three pages.

Gifts have also been received from the following:

Am. Electrochemical Soc. 1 bound vol.
Am. Soc. of Mech. Engrs. 1 bound vol., 17 pam.
Ariz. Agri. Exper. Station. 1 pam.
Baltimore & Ohio R. R. Co. 1 pam.
Baltimore, Chesapeake & Atlantic Ry. Co. 4 pam.
Biddle, John. 1 pam.
Briggs, J. A. 1 no.
Chicago, Ill.—Mayor. 1 bound vol.
Colo. Agri. Exper. Station. 8 pam.
Cornwell, R. F. 1 pam.
Corthell, E. L. 1 pam.
Croes, J. Jas. R. 1 pam.
France—Ministère des Travaux Publics. 1 vol.
Glasgow International Eng. Congress. 1 bound vol.
Great Britain—Patent Office. 10 pam.
Hale, G. W. 1 pam.
Henderson, J. B. 1 pam.
India—Director of Ry. Construction. 6 pam.
Inst. of Engrs. and Shipbuilders in Scotland. 1 bound vol.
Johnson, L. J. 1 pam.
Long Island R. R. Co. 1 pam.
McKim, Alex. Rice. 1 vol.
McMinn, T. J. 1 pam.
Madras, India—Pub. Works Dept. 1 pam.
Minneapolis & St. Louis R. R. Co. 1 pam.
Norfolk, Va.—Water Commrs. 1 pam.
North of England Inst. of Min. and Mech. Engrs. 1 pam.
Paine, Charles. 1 pam.
Parsons, W. B. 1 vol.
Poor, H. V. & H. W 1 bound vol.
Quebec & Lake St. John Ry. Co. 5 pam.
Royal Philosophical Soc. of Glasgow. 1 vol.
San Francisco, Cal.—Board of Supervisors. 1 bound vol.
Santa Fé, Prescott & Phœnix Ry. Co. 1 pam.
Thompson, Robt. A. 1 pam.
Union Pacific R. R. Co. 1 pam.
U. S. Coast and Geodetic Surv. 1 bound vol.
U. S. Commr. of Navigation. 1 bound vol.
U. S. Corps of Engrs. 28 specif.
U. S. Surgeon General. 1 vol.
Waddell, John. 1 pam.
Webster, George S. 1 bound vol.

BY PURCHASE.

La Navigation Sous-Marine à travers les Siècles, d'après de Nombreux Documents Inédits. Par Maurice Delpeuch. Paris, Félix Juven.

Le Scaphandre. Son Emploi. Par M. Dibos. Paris, Gauthier-Villars.

Grundriss der Electrotechnik für den praktischen Gebrauch, für Studierende der Electrotechnik und zum Selbststudium. Verfasst von Heinrich Kratzert. Vol. 2, Pts. 2–5. Leipzig und Wien, Franz Deuticke, 1902.

Die Telegraphie ohne Draht. Von Adolf Prasch. Wien, Pest, Leipzig, A. Hartleben, 1902.

Die Geschichte des Eisens in technischer und kulturgeschichtlicher Beziehung. Von Ludwig Beck. Vol. 5, Pt. 7. Braunschweig, Friedrich Vieweg und Sohn, 1902.

Report of the Chief Signal Officer of the Army, 1872, '75–80, '83–92. Washington, Government Printing Office, 1872–93.

American Industrial Conditions and Competition. Reports of the Commissioners Appointed by the British Iron Trade Association to Enquire into the Iron, Steel and Allied Industries of the United States. Edited by J. Stephen Jeans. London, British Iron Trade Association, 1902.

Handbuch der Ingenieurwissenschaften. Vol. 5, Pt. 7. Leipzig, Wilhelm Engelmann, 1902.

Duncan's Manual of Tramways, Omnibuses and Electric Railways of the United Kingdom and the Foreign and Colonial Companies that are Registered in England, Shewing the Dates of Incorporation, and

where Fixed and Ascertainable, the Dates at which their Leases or Concessions Terminate, with Abstracts of Accounts, Directory of Directors, Officials, Firms and Individuals Connected therewith, and Extract of Tramways Act and Bye-Laws—Board of Trade and Metropolitan. Twenty-Fifth Edition. London, T. J. Whiting & Sons, Limited, 1902.

SUMMARY OF ACCESSIONS.

From November 12th to December 9th, 1902.

Donations (including 1 duplicate and 1 number completing volume of periodical)	116
By Purchase	28
Total	144

MEMBERSHIP.

ADDITIONS.

MEMBERS.

Date of Membership.

CRUMP, RALPH LEE
Keith and Perry Bldg., Kansas City, Mo.................. Dec. 3, 1902

FERGUSON, GEORGE ROBERT
Asst. Engr., Dept. of Bridges, 1215 Park Row Bldg., New York City.. Dec. 3, 1902

HAWLEY, WILLIAM CHAUNCEY
Chf. Engr. and Gen. Supt., Pennsylvania Water Co., 701 Wood St., Wilkinsburg, Pa...
Jun. Oct, 1, 1890
Assoc. M. Apr. 6, 1892
M. Dec. 3, 1902

HOUGH, ULYSSES B
Mech. Engr., Bunker Hill & Sullivan Mining & Concentrating Co., Kellogg, Idaho.............................. Nov. 5, 1902

KLUEGEL, CHARLES HENRY
Chf. Engr., Oahu Ry. & Land Co.; Hilo R. R. Co., P. O. Box 796, Honolulu, Hawaiian Islands........................ Oct. 1, 1902

WEST, CHARLES HUNTER
Chf. Engr., Mississippi Levee Dist., Greenville, Miss...... Oct. 1, 1902

ASSOCIATE MEMBERS.

ADEY, WILLIAM HENRY
181 Main St., Cohoes, N. Y...................
Jun. Feb. 4, 1896
Assoc. M. Dec. 3, 1902

DAVIS, FRED RUFUS
Res. Engr., Indiana Branch, Buffalo, Rochester & Pittsburg Ry. Co., Juneau, Pa.................................. Nov. 5, 1902

DUFOUR, FRANK OLIVER
Prof. of Civ. Eng., Univ. of Cincinnati, Cincinnati, Ohio ....
Jun. Dec. 5, 1899
Assoc. M. Oct. 1, 1902

GIFFORD, LESTER ROBINSON
Office of Structural Engr., Cambria Steel Co., Johnstown, Pa............................
Jun. Mar. 3, 1896
Assoc. M. Dec. 3, 1902

GRISWOLD, RAY ELLIOTT
Care, Barber Asphalt Paving Co., 11 Broadway, New York City.. Oct. 1, 1902

HASTINGS, FRANK ARNOLD
21 Mawhinney St., Pittsburg, Pa .... Dec. 3, 1902

HIRST, ARTHUR
Asst. Engr., Eng. Dept., American Bridge Co., 163 Harvey St., Wissahickon, Philadelphia, Pa..................... Dec. 3, 1902

LANE, EDWIN GRANT
Asst. Div. Engr., B. & O. R. R., Cumberland, Md.......... Jan. 8, 1902

LEWIS, CLARENCE MCKENZIE
Care, Wm. Solomon & Co., 25 Broad St., New York City... Dec. 3, 1902

Date of Membership.

LIVERMORE, NORMAN BANKS
320 Sansome St., San Francisco, Cal.......... Jun. Dec. 5, 1899
Assoc. M. Oct. 1. 1902

PEMOFF, JOEL JUK
Asst. Engr., Dept. of Docks and Ferries, Pier A, North River, New York City.... .... Nov. 5, 1902

RAMSEY, EDMUND PAYTON
Asst. Engr., 1st Div., Rapid Transit R. R. Comm. (Res., 11 Flushing Ave., Brooklyn), N. Y.................................... Jun. Feb. 6, 1900
Assoc. M. Oct. 1, 1902

ASSOCIATE.

BENT, STEDMAN
Purchasing Agt., The Penna. Steel Co., Overbrook, Montgomery Co., Pa................................... Dec. 2, 1902

JUNIORS.

ARMSTRONG, ALEXANDER FLOYD
Manila, Philippine Islands .. .. Oct. 7, 1902

BRISLEY, EDWARD BETTS
Chf. Engr's Office, Manhattan Ry. Co., 102 West 75th St., New York City....................................... Dec. 2, 1902

BERRY, FRANCIS RIGDON
Care, Water Co., Birmingham, Ala.......................... Dec. 2, 1902

JACKSON, ROSCOE BRADBURY
Asst. to Dean, Dept. of Eng., Univ. of Mich., 607 Hill St., Ann Arbor, Mich....................................... Dec. 2, 1902

MANSFIELD, ROYAL JOHN
7724 Hamilton Ave., Pittsburg, Pa......................... Dec. 2, 1902

MELICK, NEAL ALBERT
Room 512, Grand Central Station, New York City........ Dec. 2, 1902

ORTIZ, EDUARDO
P. O. Box 2020, City of Mexico, Mexico............... ... Nov. 4, 1902

PARKER, RICHARD DENNY
Asst. Engr., I. & G. N. R. R., Palestine, Tex.............. June 3, 1902

PROCTOR, RALPH FENNO
U. S. Junior Engr., Campau Bldg., Detroit, Mich .... June 3, 1902

RHETT, EDMUND MOORE
1st Lieut., Corps of Engrs., U. S. A., Washington Barracks, D. C.. Nov. 4, 1902

SCHUMANN, CARL JULIUS
3 Union Pl., Troy, N. Y................................. Dec. 2, 1902

WEAVER, FRANK MAURICE
1813 North 15th St., Philadelphia, Pa.................... Nov. 4, 1902

DEATHS.

CAMPBELL, CHARLES EDWARD HENRY....Elected Member October 3d, 1883; died December 6th, 1902.

DAVIS, JOHN WOODBRIDGE..............Elected Associate June 3d, 1885; died November 7th, 1902.

Hillman, Charles Fletcher..........Elected Member July 5th, 1876; died June 14th, 1902.

Mitchell, Henry......................Elected Member January 7th, 1880; died December 1st, 1902.

Way, Robert Attwell..... ....Elected Member June 7th, 1893; died April, 1901.

Wilson, Joseph Miller..............Elected Member April 2d, 1873; died November 24th, 1902.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST.

(November 12th to December 9th, 1902.)

NOTE.—*This list is published for the purpose of placing before the members of the Society the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

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In the subjoined list of articles references are given by the number prefixed to each journal in this list.

(1) *Journal*, Assoc. Eng. Soc., 257 South Fourth St., Philadelphia, Pa., 30c.
(2) *Proceedings*, Eng. Club of Phila., 1122 Girard St., Philadelphia, Pa.
(3) *Journal*, Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal*, Western Soc. of Engrs., Monadnock Block, Chicago, Ill.
(5) *Transactions*, Can. Soc. C. E., Montreal, Que., Canada.
(6) *School of Mines Quarterly*, Columbia Univ., New York City, 50c.
(7) *Technology Quarterly*, Mass. Inst. Tech., Boston, Mass., 75c.
(8) *Stevens Institute Indicator*, Stevens Inst., Hoboken, N. J., 50c.
(9) *Engineering Magazine*, New York City, 25c.
(10) *Cassier's Magazine*, New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 25c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News*, New York City, 15c.
(14) *The Engineering Record*, New York City, 12c.
(15) *Railroad Gazette*, New York City, 10c.
(16) *Engineering and Mining Journal*, New York City, 15c.
(17) *Street Railway Journal*, New York City, 35c.
(18) *Railway and Engineering Review*, Chicago, Ill., 10c.
(19) *Scientific American Supplement*, New York City, 10c.
(20) *Iron Age*, New York City, 10c.
(21) *Railway Engineer*, London, England, 25c.
(22) *Iron and Coal Trades Review*, London, England, 25c.
(23) *Bulletin*, American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gas Light Journal*, New York City, 10c.
(25) *American Engineer*, New York City, 20c.
(26) *Electrical Review*, London, England.
(27) *Electrical World and Engineer*, New York City, 10c.
(28) *Journal*, New England Water-Works Assoc., Boston, $1.
(29) *Journal*, Society of Arts, London, England, 15c.
(30) *Annales des Travaux Publics de Belgique*, Brussels, Belgium.
(31) *Annales de l' Assoc. des Ing. Sortis des Ecôle Spéciales de Gand*, Brussels, Belgium.
(32) *Mémoires et Compte Rendu des Travaux*, Soc. Ing. Civ. de France, Paris, France.
(33) *Le Génie Civil*, Paris, France.
(34) *Portefeuille Économique des Machines*, Paris, France.
(35) *Nouvelles Annales de la Construction*, Paris, France.
(36) *La Revue Technique*, Paris, France.
(37) *Revue de Mécanique*, Paris, France.
(38) *Revue Générale des Chemins de Fer et des Tramways*, Paris, France.
(39) *Railway Master Mechanic*, Chicago, Ill., 10c.
(40) *Railway Age*, Chicago, Ill., 10c.
(41) *Modern Machinery*, Chicago, Ill., 10c.
(42) *Transactions*, Am. Inst. Elec. Engrs., New York City, 50c.
(43) *Annales des Ponts et Chaussées*, Paris, France.
(44) *Journal*, Military Service Institution, Governor's Island, New York Harbor, 50c.
(45) *Mines and Minerals*, Scranton, Pa., 20c.
(46) *Scientific American*, New York City, 8c
(47) *Mechanical Engineer*, Manchester, England.
(54) *Transactions*, Am. Soc. C. E., New York City, $5.
(55) *Transactions*, Am. Soc. M. E., New York City, $10.
(56) *Transactions*, Am. Inst. Min. Engrs , New York City, $5.
(57) *Colliery Guardian*, London, England.
(58) *Proceedings*, Eng. Soc. W. Pa., 410 Penn Ave., Pittsburg, Pa., 50c.
(59) *Transactions*, Mining Inst. of Scotland, London and Newcastle-upon-Tyne.
(60) *Municipal Engineering*, Indianapolis, Ind., 25c.
(61) *Proceedings*, Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *American Manufacturer and Iron World*, 59 Ninth St., Pittsburg, Pa.
(63) *Minutes of Proceedings*, Inst. C. E., London, England.
(64) *Power*, New York City, 20c.
(65) *Official Proceedings*, New York Railroad Club, Brooklyn, N. Y., 15c.
(66) *Journal of Gas Lighting*, London, England, 15c.
(67) *Cement and Engineering News*, Chicago, Ill., 25c.
(68) *Mining Journal*, London, England.

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The Reasons for the Change of the Navy Standard Voltage from 80 to 125. W. V. N. Powelson. (42) Oct.
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A Proposed Standard for Machine Screw Thread Sizes.* Charles C. Tyler. (55) Vol. xxiii.
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A Silent Chain Gear.* J. O. Nixon. (55) Vol. xxiii.
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The Flying Shear.* V. E. Edwards. (55) Vol. xxiii.
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AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

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Vol. XXVIII. DECEMBER, 1902. No. 10.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

AN ALTERNATIVE LINE FOR THE NICARAGUA CANAL; AND A PROPOSED NEW METHOD OF DAM CONSTRUCTION.

Discussion.*

By Messrs. P. C. Hains, Alfred Noble, Edward P. North, L. M. Haupt and Theodore Paschke.

Mr. Hains. P. C. Hains, M. Am. Soc. C. E.—This project for an alternative route for a Nicaragua Canal comes rather late, inasmuch as the question of route seems to have been settled definitely in favor of Panama. It is understood that the author was employed in Nicaragua by the Maritime Canal Company for a period of about two years, and has given the subject of a Nicaragua Canal a good deal of study. His opinions, therefore, are entitled to consideration. Time will not permit of an extended treatment of this paper, and, under the circumstances, it seems unnecessary, but it is proposed to offer a few comments on certain salient points.

The Isthmian Canal Commission, in its report of 1899–1901, submits a project for a canal in Nicaragua substantially on the route suggested by the Nicaragua Canal Commission in 1898. Starting from Brito, on the Pacific coast, the line follows close to that proposed by Colonel Childs in 1850 to Lake Nicaragua. It then crosses Lake Nicaragua and follows the San Juan River, which it is proposed to canalize, to the neighborhood of the junction of the San Carlos

* This discussion (of the paper by J. Francis Le Baron, M. Am. Soc. C. E., printed in *Proceedings* for October, 1902), is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.
Communications on this subject received prior to January 23d, 1903, will be published subsequently.

with the San Juan; thence it follows the valley of the San Juan on the north side of the stream. The alternative line proposed by Mr. Le Baron refers only to that part of the route lying between the neighborhood of the junction of the San Carlos with the San Juan and the Caribbean Sea, and passes to the sea on the south side of that stream. Mr. Hains.

The author states that:

"The importance of good harbors for the termini of the Nicaragua Canal is so great that we could well afford to sacrifice several less favorable features to secure them."

This is true, but there are some features which cannot be sacrificed for any reason. A perfectly practicable plan for a canal cannot be sacrificed for one of uncertain practicability; a plan that is free from all experimental constructions should not be sacrificed for one that is not.

At the present time there is no harbor at either end of a Nicaragua Canal, and this is true whether the route be that of the Isthmian Canal Commission, or the one proposed by the author. Harbors will have to be constructed at each end of the line. Why, then, should any features of a feasible route be sacrificed to obtain what does not exist?

That it is practicable to construct a harbor at the Colorado mouth of the San Juan will not be questioned, but that one exists at the present time cannot be truthfully asserted. Indeed the author seems to admit this fact, for he states that he "considers it" (the mouth of the Colorado) "well adapted for improvement by jetties"; and, also, that there "seems to be little reason for doubt that this channel can be deepened to 24 ft. by jetties alone." As a matter of fact, very little is known about the actual conditions at the Colorado mouth of the San Juan River. A survey was made in 1865 by Mr. P. C. F. West, of the United States Coast Survey; and another was made by Commander Tilly, of the United States Navy, in 1898. Neither is really entitled to the name of survey. Only a few soundings were taken on the bar by either West or Tilly, and no tidal measurements were made or other data necessary for formulating a project of improvement obtained. The locality was visited by the Nicaragua Canal Commission in 1898, and again by the Isthmian Canal Commission in 1900. At the time of the latter visit the remains of a wreck were plainly visible off the mouth of the entrance, and the sea, though the weather was normal, was breaking across the entire length of the bar. The "condition of nearly stable equilibrium," which, the author claims, exists there, was not apparent at either time. Still, it will be admitted that the channel might be deepened by the construction of jetties, or by jetties combined with dredging.

The author seems to think that the construction of a harbor at or ear Greytown is impracticable. In this he differs from nearly every

Mr. Hains. engineer who has studied this question. Many will differ as to the cost of construction. Some may differ as to the causes of the destruction of the old harbor. Some may differ as to the best site available in the immediate vicinity; but none is known to admit that the construction of a harbor is impracticable. The sand movement at Greytown is very similar to that at the Mediterranean end of the Suez Canal, and certainly no one will question the fact that a harbor at the entrance of that canal has been obtained and successfully maintained.

"The futility of building a harbor in the re-entrant angle" (near Greytown), the author states, "is exemplified still further by the experience of the Maritime Canal Company"; and that "the jetty built by them has been overwhelmed by the sands, and the channel they had cut through the littoral cordon enclosing the harbor lagoon filled up shortly after the work stopped."

It is quite true that most of the partially constructed jetty was overwhelmed by the sand, and the channel filled up shortly after the work stopped; but it is remarkable that the engineers composing the Isthmian Canal Commission, as well as others, should draw from the experience of the Maritime Canal Company, in its attempt to form a harbor at Greytown, diametrically opposite conclusions from those formed by the author. This is more particularly strange in view of the fact that the author was employed by that company at about the time the jetty was constructed. The Isthmian Canal Commission states in its report as follows:*

"The feasibility, moreover, of constructing a harbor at Grey Town has been practically demonstrated by the work done by the Maritime Canal Company. About 1 000 linear feet of jetty was constructed by that company at a place a short distance west of the location proposed by this Commission, and where the conditions of sand movement are identical. This was quickly followed by the scouring out of a channel on the lee side to a depth of about 7 ft. This channel was made through the sand spit which converted Grey Town Harbor into a lagoon. The channel was increased in depth to 12 or 14 ft. by dredging. No difficulty would have been experienced in deepening this channel still more, and in maintaining the increased depth by the further extension of the jetty seaward aided by dredging and the possible construction of another jetty on the west side."

It is to be borne in mind that less than 1 000 ft. of jetty were constructed, and the outer end of it, at the time work was stopped, was nowhere near the 30-ft. contour, beyond which it was expected to go to secure the required depth, but the moving sands were arrested by it and accumulated on the windward side, as was expected. The outflow from the lagoon, without other help, opened a channel for itself, 7 ft. deep, which was increased to about 14 ft. by dredging. That a short piece of unfinished jetty should have produced such results so quickly is believed to establish beyond all doubt, if doubt exist, the practicability of thus opening a harbor. The canal engineers regarded

* Report of the Isthmian Canal Commission, 1899-1901, p. 141.

it as a practical demonstration of the correctness of the theories on which the plans were based. That a further extension of the jetty (which the plans contemplated) would have been followed by a channel of still greater depth is not to be doubted; that in its unfinished condition it should have been overwhelmed by the sands after work stopped, was to be expected. That this sand movement in the near vicinity of Greytown is objectionable, no one will deny; but that it cannot be stopped by groynes or jetties built out from the shore, no engineer familiar with such work would be willing to assert. It is a far easier problem to solve than many others that are encountered on any Isthmian Canal route. It is chiefly one of expense, and not a very serious one, at that. Mr. Hains.

The author is in error when he states that "strange to say, only one location for the harbor has been proposed." If he had read the report of the Isthmian Canal Commission* he would have found that an alternative location for a harbor near the mouth of the Indio, about 6 miles northwest of Greytown, is discussed. Not only was the question of a harbor at that point discussed, but an alternative route for the canal from Lock No. 1 to the harbor site was surveyed. The Commission states as follows:

"As already stated, the movement of the sand along the coast, which at Grey Town seems to be at the maximum, decreases as the mouth of the Indio is approached. This stream doubtless brings down some sand and silt during floods. The amount is unknown, but is probably small. Immediately north of its mouth a forest growth, fringing the ocean front, indicates that the shore line is not now being subjected to much change. In view of the small sand movement in the neighborhood of the mouth of the Indio and the apparent stability of the shore line there, it was thought advisable to locate an alternative route from Lock No. 1 to a harbor site at that place."

* * * * * * * *

"This alternative route is of about the same length as the adopted one to Grey Town, but has a little less curvature. The fore shore of the coast is flatter than in the vicinity of Grey Town, requiring longer jetties to secure a harbor. The jetties should converge seaward to give a large area outside the shore line in which the force of the waves may expend themselves, as at Ymuiden. The first cost of this alternative route, both for excavation and harbor jetties, would be greater than that of the adopted one. There is reason to believe, however, that the cost of maintaining the harbor would be less, and possibly the saving in this respect would be sufficient to warrant the greater expenditure for construction."

* * * * * * * *

"The data concerning the Indio route are not so well ascertained as those relating to the adopted route terminating at Grey Town, but its advantage in respect to maintenance of the harbor can hardly be doubted. The Commission believes, however, that it is practicable to maintain a harbor at Grey Town which will be fully as serviceable in every way, and regards its advantages as a working harbor as of such importance that its estimates are based on that location."

* Report of the Isthmian Canal Commission, 1899–1901, pp. 162 and 163.

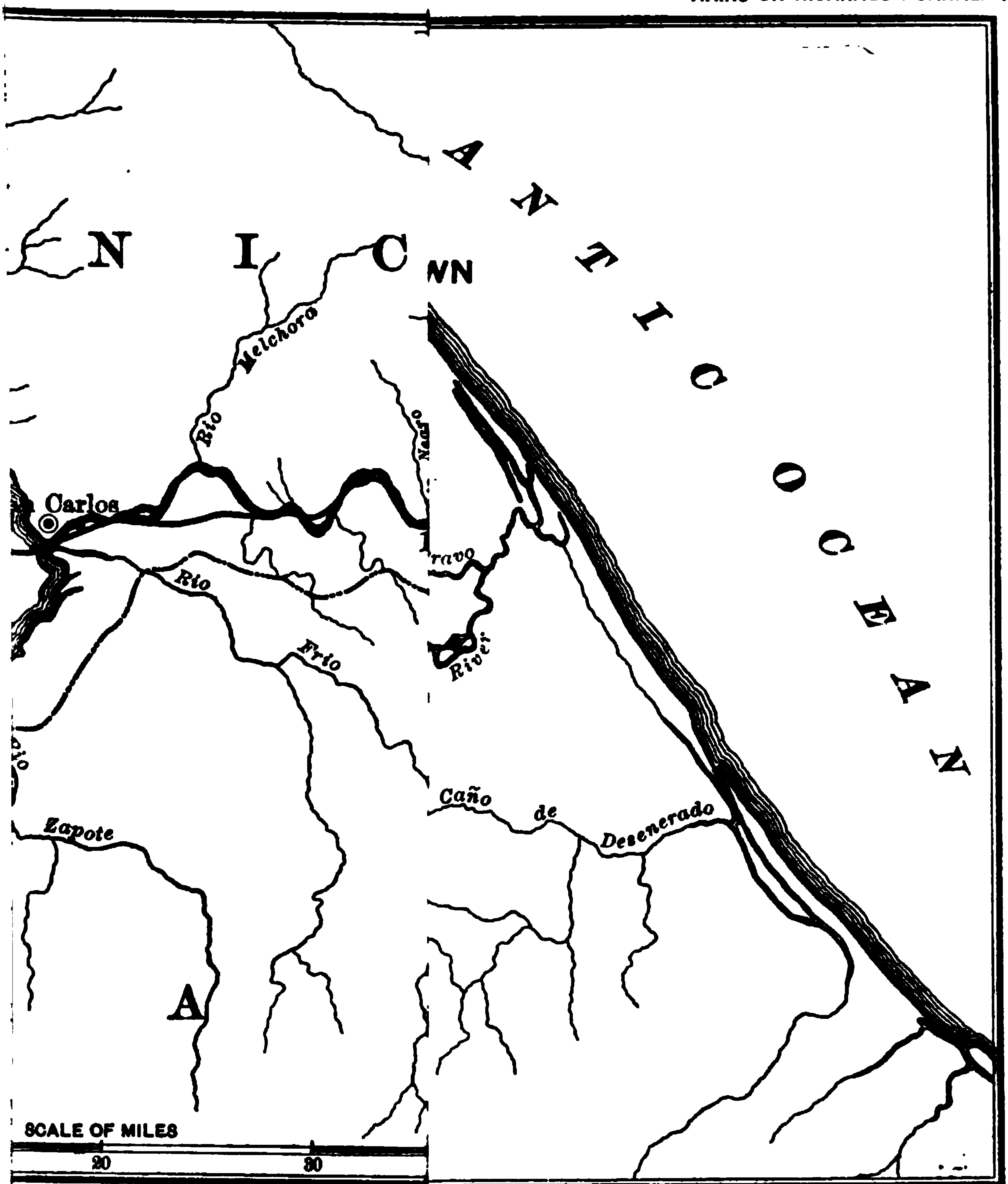
Mr. Haine. The Isthmian Canal Commission does not claim originality in the suggestion of this alternative harbor. Its possible advantages have occurred to others, before. It shows either that the author has not read the report of the Isthmian Canal Commission, or read it to little effect. He says that "The last Isthmian Canal Commission dismissed the idea of a canal on the south side of the San Juan in a few words," and quotes what purports to be a statement of the Chief Engineer to sustain him. There was only one Isthmian Canal Commission. He has the Nicaragua Canal Commission mixed up with the Isthmian Canal Commission, and in reality is referring to the former. The statement of the Chief Engineer of the Nicaragua Canal Commission is as follows:

"An examination of the map shows that a canal location from the Caribbean Sea to Lake Nicaragua, south of the San Juan River, would cross all of these streams." (Referring to the Frio, Poco Sol, San Carlos and Serapiqui.) "This would make its construction practically an impossibility."

The Nicaragua Canal Commission is not responsible for the statement of its Chief Engineer, but it is submitted that this Chief Engineer's statement is absolutely correct. He says that a canal location from the Caribbean Sea to Lake Nicaragua, south of the San Juan River, would cross all these streams, and so it would, as will be seen by an examination of the map, Plate XL. In the plans submitted by the Nicaragua Canal Commission it was proposed to canalize the river from the lake to near the mouth of the San Carlos; but that was not the plan to which the Chief Engineer referred.

Assume, for the sake of argument, that there may exist a good harbor at the mouth of the Colorado, which is by no means admitted; what are the "less favorable features" of a canal that it is proposed to sacrifice in order to secure it?

First.—The San Carlos must be taken into the canal or canalized river. The canalized river then becomes practically an extension of the lake level to the dam, exactly as suggested by Mr. Menocal. The San Carlos is a torrential stream of no mean dimensions. It takes its rise in the mountains of Costa Rica, and drains a large but unknown area of country. It brings down immense quantities of volcanic sand which have been deposited in the San Juan River from its junction with the San Carlos to the sea. It is an accepted theory that the delta of the San Juan has been largely built of the sand brought down by this river. The sand that now obstructs the bar at the mouth of the Colorado is believed to have come from the mountains of Costa Rica by way of this river and the Serapiqui. In appearance, the sand in the San Carlos bed and that in the delta are identical. When this river is in flood the discharge is estimated by Mr. A. P. Davis, the hydrographer of the two commissions that reported on a Nicaragua Canal Route, as reaching the large



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/ Isthmian Canal Commission.

amount of 100 000 cu. ft. per second. The San Juan, above its junction with the San Carlos, Mr. Davis' estimates may also reach 100 000 cu. ft. per second when the lake is high and the tributaries of the stream above the mouth of the San Carlos are discharging their flood waters into it. The possible discharge of the two rivers combined make a total of 200 000 cu. ft. per second. An actual measured discharge, made near Ochoa in 1900, was more than 130 000 cu. ft. per second. Mr. Hains.

The difficulty of handling this enormous quantity of water is so great that any prudent engineer would prefer to have it eliminated from consideration. It is practicable to eliminate it by constructing the canal on the north side of the river, and as no apparent advantages are gained by taking the south side, all engineers, from Colonel Childs in 1850 to those on the last canal commission, preferred the north side. The first sacrifice, therefore, made to secure this mythical harbor at the Colorado, is the taking of this torrential stream into the canalized river rather than avoiding it altogether.

Second.—The Serapiqui must be taken into the canal. This the author proposes to do in a short section between locks which he proposes to locate on opposite sides of the river. The bed of the Serapiqui is to be used as a part of the canal, but that does not affect the question materially. The full discharge of the Serapiqui must be taken into the canal and let out again. This river is very much like the San Carlos, except that it is not so large. It takes its rise in the mountains of Costa Rica, and brings down large quantities of volcanic sand. Mr. Davis, the hydrographer already referred to, estimates that the discharge of this stream may reach 66 000 cu. ft. per second. To take this quantity of water into a long and wide section of canal would be a hazardous undertaking. To take it into a short section would be still more difficult. Actual measurements of the discharge of this stream exceed 26 000 cu. ft. per second.

The author states that the crossing of the Serapiqui is not more difficult than that of the San Francisco, which is on the north side of the San Juan, "except in degree." A 12-in. projectile striking the armor of a battleship with a velocity of 100 ft. a second will do comparatively little or no damage; but, let it strike with a velocity of 2 000 ft. a second and it may destroy the ship. Yet there is no difference between the two cases except in degree of velocity. The statement that the Serapiqui is only about twice the size of the San Francisco is an error, and a bad one. The Nicaragua Canal Commission made a series of gaugings of these two streams in 1898–1899. These gaugings are published in the report of the Nicaragua Canal Commission. The measurements of the San Francisco, made at the lower station, near its mouth, extended over a period of nine months; those of the Serapiqui, 5 miles above its junction with the San Juan, extended over a period of 11

Mr. Hains. months. The minimum, recorded, low-water discharge of the San Francisco was 66 cu. ft. per second. The minimum recorded discharge of the Serapiqui was 2 240 cu. ft. per second. The maximum high-water discharge of the San Francisco was 550 cu. ft. per second, and that of the Serapiqui was 26 731 cu. ft. per second. These were actual measurements made by careful men. They show that in the low stages the Serapiqui discharges about thirty-four times as much water as the San Francisco, and in the high stages nearly fifty times as much. Comment is unnecessary.

Third.—The Caño Negro must also be crossed. Our knowledge of this stream amounts to almost nothing. The maps show its existence. Apparently, it drains a large area of Costa Rican territory, and may be a stream of very large size; but the known physical data in regard to it amount practically to nothing. What difficulties may be encountered in crossing this stream are absolutely unknown.

Fourth.—The Conchuda dam site must be sacrificed for the one at Ochoa. That is, a perfectly practicable dam which involves no untried engineering problems in its construction, is to be given up for a dam the like of which has never before been proposed to the engineering profession, much less built. Whatever opinions may be held with reference to this dam, it is not asserted that it cannot be built. That question will be passed over without other claim than that the building of any dam at Ochoa is a work of great difficulty, while the building of a dam at Conchuda is not; that the dam proposed is experimental; and that the interests involved are so immensely great that, under the circumstances, no engineer would be justified in adopting it. A masonry dam at Conchuda is safe and practicable. It is true that the cost of the project is apparently increased by the acceptance of these safe conditions, but cost is one of the features that can be sacrificed to that of safety in a work of such importance as an Isthmian Canal. What engineer would not prefer to incur an expense of millions of dollars in order to make such an important structure safe? There is to be considered not only the question of money, but that of life also. The destruction of the dam would mean, not only great financial loss, but a fearful loss of life besides.

What are the peculiarities of the dam that the author proposes that are to render it safer than the ordinary rock-fill dam? It is proposed to inclose the loose rock composing the dam within a net made of 1-in. steel cables, the meshes of the net being 3 ft. square and crossed by meshes of still smaller cable. This net is to be laid on the bottom of the river and the dam built upon it. As the work progresses, the up-stream and down-stream ends of the net are to be drawn up, and when the stone fill is completed, the ends of the net are to be fastened together, forming a huge bag of stone.

The author is entitled to full credit for originality in this dam. He says that "an earthquake would only serve to consolidate it and fill up the voids." It is the only dam known that is improved by earthquakes! But has the possibility of the steel cables wearing out, been considered? Has the fact, that in some waters iron and steel undergo chemical changes which destroy their properties, been considered? Has the wearing effect of the sand, washed over the dam by the mighty currents passing over it, been thought of? Steel bolts 1 in. in diameter have been known to be worn through in 24 hours when exposed to the rasping effect of sand in an ordinary centrifugal pump. One of the great difficulties of holding a lightship in position is that the motion of the ship wears out the chain where it comes in contact with the sand at the bottom of the sea. Mr. Hains.

It is stated that the method of construction will present no difficulties. As the method of construction is not explained, it is not clear that such is the fact. How, for instance, will the lower slopes of the dam be maintained at 1 on 4 during construction if it be overtaken by a great flood? Can anyone say that loose stone, even of large size, will stand on that slope under such circumstances? Will there be no difficulty in drawing up the net on the down-stream side with a mighty torrent passing over it?

The author proposes to construct two spillways in the San Carlos embankment, but says his dam "would be perfectly safe as a weir." It is not claimed that the surplus water may not be discharged over spillways in the San Carlos embankment; but the structures, to be safe with such immense quantities passing over them, should be founded on rock. Possibly a good rock foundation near the surface can be found, but it is not known that it can.

That such a dam could be used safely as a weir, cannot be admitted. To use it for that purpose will necessitate that it be made not only water-tight, because the level of the lake is to be regulated by this weir, but the gates, to regulate the flow of this enormous mass of water over it, must be adjustable and built on top of it. Would any engineer wish to build adjustable, water-tight gates on top of that bag of stone with 100 000 and possibly 200 000 cu. ft. of water passing over it?

The claim that this is not an experimental dam, because a small one has been built in a small stream with sand bags instead of stone, and an ordinary twine net instead of a chain cable net, cannot be accepted. Such a dam, to say the least, is unquestionably experimental. None like it has ever been built under similar conditions. Yet the safety of the entire canal project, involving the expenditure of $150 000 000 to $175 000 000 will depend on this dam. An experimental structure of such a nature has no place in a great project like

Mr. Hains. that of an Isthmian Canal, where so many and such vast interests will be centered.

The members of the Isthmian Canal Commission approached the canal problem with the feeling that a grave responsibility rested on their shoulders. In the minds of the Commission it was a matter of supreme importance that no constructions should be adopted that it was not perfectly feasible to build, and when built, to be safe beyond all peradventure, barring extraordinary convulsions of Nature, for which provision could not be made. It aimed to adopt only such types of structures as had been tested successfully elsewhere under similar conditions, and to reject all structures of a novel type which had not been thus tested. The question of cost was not ignored, but, in the consideration of the problem, it was given a place secondary to that of safety and feasibility. Treating the subject from that standpoint, the Commission recommended a project which was free from all unsafe or questionable structures. Will it not be said that, in this, the Commission was right?

Mr. Noble. ALFRED NOBLE, M. Am. Soc. C. E.—The decision by Congress at its last session, favoring the Panama route, may seem to make the subject of the author's paper a dead issue. This decision, however, was subject to the express condition that the United States should be given perpetual control of the immediate vicinity of the route. This condition was wisely interposed, for the Isthmian Canal problem is no less one of sanitary than of civil engineering. If such control cannot be had at Panama and can be obtained for the Nicaragua route, it would be better to accept the latter. To attempt the building of a canal in either place without such control would be to invite the discredit and disaster which have attended previous work at Panama.

It may help to a better understanding of the paper if a brief reference be made to the principal surveys of the route.

The first survey worth mentioning was made by Colonel O. W. Childs, in 1850 to 1852, for Cornelius Vanderbilt and his associates. His project was for a canal 17 ft. deep. His report was a model as an engineering report, and has been the basis for the best of the work done since. His line followed the river from the lake to the mouth of the Serapiqui, thence by canal to Greytown. Greytown then had an excellent harbor, but, a few years later, a sand bar extended across it and it became a lagoon. The next survey, omitting other mention of the work of the United States Coast Survey in 1865 on the lower river, was made by the United States Navy in 1872–3, and is known as the Lull Survey, from the name of the officer in charge during the last year. Lull's line left the San Juan a short distance below the mouth of the San Carlos, and thence a canal was located on the left bank of the San Juan to Greytown. This passed through Silico Lagoon and was approximately the line shown on the author's

map (a reproduction mainly of the map of the Nicaragua Canal Commission) as "Lull Route Variant II." The other "Lull Variants," shown on the map were not run by Lull, were not shown on his published maps or referred to in his report, and the speaker knows no reason for thus terming them. Mr. Noble.

After the Lull survey came the series of surveys made under the direction of A. G. Menocal, M. Am. Soc. C. E., first as an officer of the United States Navy, and next as Chief Engineer of the Maritime Canal Company, the latter covering a period of about five years, ending in 1893. In these surveys Mr. Le Baron had a responsible part. The principal result of these was the development of a cut-off line, from the mouth of the San Carlos to Greytown, which had some advantages. Like many other projects in connection with this route its difficulties developed rapidly with more detailed examination.

Since the suspension of work by the Maritime Canal Company, three examinations have been made by commissions sent out by the United States Government. As the author has fallen into some confusion with regard to these, it seems necessary to name them. The first was the Nicaragua Canal Board, whose work was done in about six months in 1895. The second was the Nicaragua Canal Commission, appointed in 1897. This commission had at its disposal about $300 000, and made more careful surveys and studies than had been accomplished previously. It completed its work and disbanded in 1899. The author has availed himself of these data, but seems to have the impression that they were the work of the third commission, the Isthmian Canal Commission, which is still in existence, in a state of suspended animation. The author's references to this commission are erroneous. The first two commissions were concerned only with the Nicaragua route. The last was charged with the broad question of Trans-Isthmian Canal communication. About $1 000 000 were placed at its disposal, and four-fifths of this sum were expended for the Nicaragua route. The United States and the Maritime Canal Company have expended a total of about $1 500 000 in surveys of the Nicaragua route, and probably two-thirds of this have been expended in the region shown on the author's map—about one-quarter of the route in length.

There was good reason for this concentration of expenditure on so short a section, for here are great difficulties and many alternatives. They are less in other sections. From Lake Nicaragua to the Pacific the route discovered and adopted by Colonel Childs has been accepted by all his successors save one. It was a satisfactory solution of the problem in that section. Of the lake section nothing need be said here. The upper river section, extending from the lake to the vicinity of the mouth of the San Carlos, some 60 or 65 miles by the river, has its best practicable solution in the building of a great dam across the San Juan River, near the mouth of that tributary, to form a so-called

Mr. Noble. slack-water navigation above. The navigation thus obtained would still be somewhat hazardous on account of the numerous curves and occasional strong currents, but the tributaries above the San Carlos bring in little sediment; and a channel, once made, could be easily maintained.

The real problems of the Nicaragua route are the regulation of lake level, and the location, construction and maintenance of the section from the mouth of the San Carlos to the sea; they will be referred to in inverse order.

Below the proposed site of the San Juan dam the tributaries on the left bank of the San Juan are small. The largest, the San Francisco, drains an area of perhaps 65 sq. miles, and has a maximum discharge of possibly 4 000 cu. ft. per second. The other streams are smaller. On the opposite side of the San Juan the divide is about 50 miles distant, and is a lofty range of mountains with volcanic peaks rising to 12 000 ft. Commencing with the San Carlos and going eastward and southward, all the streams flowing down the slopes of these mountains carry sand. The San Carlos, the largest tributary of the San Juan, has a maximum discharge of probably 100 000 cu. ft. per second. It transforms the channel of the San Juan from a stable one to a mass of shifting sand bars. The Costa Rican volcanoes have been known to erupt vast quantities of sand, and are supposed to be the main source of the supply brought down by the San Carlos and other streams.

About 23 miles below the mouth of the San Carlos the San Juan receives through its right bank its next largest tributary, the Serapiqui. This stream has an estimated maximum discharge of about 60 000 cu. ft. per second. Like the San Carlos, it drains the northern slopes of the Costa Rican volcanoes; and, again, like that stream, it is a great sand bearer. The author proposes to dam the Serapiqui. So far as known, no great pool could be formed to stop the moving sand at a safe distance from the canal. To maintain the full depth of the canal at the crossing would be at best an expensive undertaking. If no pool of magnitude could be formed the maximum discharge would have to pass over waste-ways. These would be works of great magnitude, second only to those required in the neighborhood of the mouth of the San Carlos. These considerations have been generally considered fatal to a canal location on the right bank of the San Juan.

The parties employed by the Isthmian Canal Commission have developed considerable topography not shown on the author's map; and that map shows some topography not yet seen except by the eye of faith; it would be difficult, however, for one not familiar with the tropical forest conditions, to understand why such small results have been obtained from the large expenditures made in this section. Yet

the expenditures have been made carefully, the work has been done Mr. Noble. with zeal and intelligence, and the apparently small results are due to the peculiarly difficult conditions. In the hill sections one may walk the ridges at a rate of 2 or 3 miles per hour; but in locating canal lines one seeks level ground, which in this region of heavy rainfall is always swampy; here, a transit line, cut through the dense vegetation, resembles a tunnel, and a mere reconnoissance is a formidable undertaking. The trees are much taller in the low ground than on the hills, so that, when viewed from a tree-top or other elevated point, a country of low hills and ravines will look like a level plain. A line may pass within 50 ft. of a hill and its existence remain unsuspected until cross-tunnels are cut for cross-sectioning. In such a country hardly anything is known of the topography except within very short distances of the line run. With a pretty full knowledge of these conditions the speaker must question whether the information concerning the topography along the proposed route is as well known as our sanguine author believes, and has no doubt that those long captivating tangents would suffer if the line were surveyed. It is not likely that the alignment would be materially better than that now obtained on the left bank of the San Juan where the minimum radius is about 5 000 ft., excepting a single curve in the broad harbor channel at Greytown.

It has been held by many that if the Caribbean terminus were located south of the mouth of the Colorado it would remain clear of sand, the San Juan being considered the only channel supplying it, and the drift of sand being supposed to be entirely northward. The investigations of the Nicaragua Canal Commission showed that the sea shore is of sand, as far south, at least, as the mouth of the Reventazon, which drains the southern slopes of the Costa Rican volcanoes; and all the streams of this coast may be sand bearers. To the north of the mouth of the San Juan the sandy beach extends for a long distance, but the streams are not believed to be sand bearers.

The direction of the littoral current appears to be variable. The author states that he observed a westward current "between Harbor Head and the canal mouth" which corresponds to a current up the coast to the northward. The Chief Engineer of the Nicaragua Canal Commission states: *

"The littoral current off this coast is for the most part southward. On the hydrographic charts it is so marked with a velocity of from one to two knots per hour. During the year 1898 it ran southward about eleven months. When the trade winds were mildest the southerly current diminished and finally stopped and then flowed gently northward for about one month. I was told by the sailors and fishermen that this change in the direction of the current was expected by them each year."

It would seem that the author's observations were taken during the

* "Report of the Nicaragua Canal Commission," p. 61.

Mr. Noble. comparatively small portion of the year when the current was northerly. The Chief Engineer concludes* that the sand is "not carried by the littoral current, * * * but is urged along the shore by wave action."

The northeast trades blow almost constantly on this coast, which, except in the bight of Greytown, has a general direction only a little west of north. It is not a little puzzling why the trades should produce a sand movement northward. On two occasions the speaker visited the shore a little south of Harbor Head; once near the head of Agua Dulce Lagoon, 6 or 8 miles to the southward, and once near the mouth of the River Indio, about the same distance to the northward, and on both these occasions the sand movement at the beach was to the southward, although small in amount. The speaker does not attach much importance to these few casual observations. The form of the lagoons near the Colorado mouth, as well as the form of the present outlet, strongly indicate a northerly sand drift in that vicinity. He is inclined to believe, however, that the present movement is not great anywhere, except on the westerly stretch of shore from the point at Harbor Head to the re-entrant angle at the head of the bight. In this stretch the waves raised by the northeast trade fall obliquely on the coast and produce a great sand movement to the westward. This does not extend in large quantity beyond the re-entrant angle of the coast line, the sand being caught and held in the bight. Although the indications are strong that the streams are now bringing down less sand than formerly, the sand movement to the head of the bight may be nearly or quite as great as ever, the sand being now supplied by erosion from the point of Harbor Head, the action now going on being a straightening of the shore line.

For various reasons the canal entrance near Greytown has been located in the Greytown bight. One of these reasons, which it is understood controlled the Maritime Canal Company, was the political necessity of placing it in territory undoubtedly Nicaraguan, the exact boundary not having been defined at that time; another reason was to avoid crossing the lower San Juan, one of the delta outlets of the main river, which, even in its reduced condition, is still a large stream and is supposed to carry some sand; and another is the more sheltered entrance to the harbor.

Any harbor jetty located along this westerly stretch of coast will intercept the sand drift, and a harbor will have to be maintained by dredging. The amount may be anywhere from 500 000 to 1 000 000 cu. yds. per year. The entrance to the Suez Canal at Port Said is maintained in the same way under like conditions. The speaker concurs with the majority of those who have looked into the subject, that this disadvantage, considerable as it is, is less than would be

* *Ibid*, p. 62.

encountered at the crossing of the Serapiqui by a canal on the south side of the San Juan. Mr. Noble.

There appears to be little sand movement north of the Greytown bight. This has led different engineers to propose a harbor near the mouth of the Indio, where the conditions for economical maintenance are probably as favorable as anywhere on the coast.

The speaker will not discuss at length the proposed plan of dam construction. Its location below the mouth of the San Carlos is necessary, for the author's route, to avoid choking the canal with sand at the crossing of the San Carlos. The great pool thus formed would extend several miles above the crossing, and the sand would be dropped at the head of the pool. There being no rock foundation within reach, a rock-fill is perhaps the only dam construction practicable at any point below the mouth of the San Carlos. The great objection to such a dam, with an overflow as designed by the author, is that it will not fully serve the purposes for which a dam is required.

In its natural state Lake Nicaragua has an extreme oscillation of from 10 to 15 ft. The variation in any single year may not greatly exceed 6 or 8 ft. If the project of the Isthmian Canal Commission should be carried out, the length of the summit-level from the San Juan dam, up the San Juan River, then across Lake Nicaragua and the continental divide beyond it to the first lock, will be about 135 miles, of which 69 miles will require deepening. Obviously, every foot in depth of excavation is a large amount, and it is extremely desirable to hold the level of Lake Nicaragua as high as practicable. At the same time it is not permissible to raise the high stage of the lake above the normal. The attempt has been made, therefore, to design regulating works which will enable the extreme oscillations of the lake to be reduced to about 6 ft., the range being measured from normal extreme high.

In the lake region the year is divided into two seasons, a wet and a dry. One of the important results of the work of the Nicaragua Canal Commission was the discovery of the fact that during some years the lake inflow is less than the evaporation, and the outflow is at the expense of storage. It would be necessary to build the canal works so that at the close of the wet season the outflow from the lake could be stopped entirely. The crest of the dam, therefore, must be at high-water level or higher. An overflow dam with a fixed crest is inadmissible.

On the other hand, to prevent too high a stage during a wet season of excessive precipitation, provision must be made for a very large discharge from the summit-level. For this, a low crest is required. These two requirements, a high crest during one set of conditions and a low crest during another set, result in a movable dam.

Mr. Noble. The author's dam, therefore, must be built above the highest water level and have no overflow at any time. Waste-ways with movable crests, or possibly under-sluices, must be provided with a capacity of more than 100 000 cu. ft. per second. No suitable locality with rock foundations at moderate depths is known, and the constructions required would be enormously expensive. A few miles above the mouth of the San Carlos a site has been found where a masonry dam can be placed across the river on solid rock, its crest provided with movable weirs which can be supplemented by a waste-way of similar character on a favorable site, to any extent necessary, and all at reasonable cost. The location above the mouth of the San Carlos is believed to be preferable, not only by reason of more favorable conditions for building, but because it is not necessary to provide for wasting the San Carlos floods.

The speaker believes that the line proposed by the author introduces more serious difficulties than it avoids, and that the dam does not meet the requirements of the problem.

* The plan of placing regulating weirs in the San Carlos Ridge has been studied for twelve or more years, and by the three United States Commissions, among others. It is to be considered only in connection with the Ochoa Dam which is located where the San Carlos Ridge terminates, at its northerly end, at the San Juan. This place was not considered favorable for a dam by either of these Commissions, and attention was first given to the search for a better one and with success; the San Carlos Ridge does not connect with the new dam site, and no further physical examination of it was made. At the new dam site, rock is within easy reach by the pneumatic process, the rock in the adjacent hills affords satisfactory abutments, and a large quantity of water could be passed over it without danger to the structure. In the connecting ridge on the San Carlos side an excellent site was found for a waste-way where hard rock at a moderate depth was developed by borings. The two waterways, counting the dam as one, both equipped with movable dams or sluices, would give a safe control of the summit level of the canal.

There are several small gaps or saddles in the San Carlos Ridge where the ground is below, or but little above the proposed summit level. The engineer of the Maritime Canal Company proposed to build several small weirs and sluices in the ridge, and, at two sites, made a few borings which do not appear to have reached rock, although sunk to considerable depths. The quantity of water to be discharged was greatly under-estimated. The material, a hard clay, might have served for foundations of small structures, but waste-ways for the discharge of, say, 200 000 cu. ft. of water per second would be enormous structures, and should be founded on hard, sound rock.

* Added to the original discussion after reading Mr. North's question on page 843.

With rock surface as far down as it appears to be in the San Carlos Ridge, the cost of such structures would be very great. Mr. Noble.

The clay hills in Nicaragua appear to have been formed entirely by rock decay at the places where they now exist. Many borings have been made on the left bank of the river on the located canal line of the Isthmian Canal Commission. In the vicinity of Ochoa the rock is lower and its upper portion more decayed than further up the river.

The question as to the discharge of the water of the San Francisco implies the canal location through the so-called East Divide. Of course, the waters could be thus discharged, but they could be wasted quite as well over a waste-way in their own valley as to be conducted through several canal sections, thus setting up currents therein. The waste-way would be a small structure. The discharge from the San Francisco is smaller than formerly supposed.

Mr. North. EDWARD P. NORTH, M. Am. Soc. C. E.—Have those who are studying this Isthmian Canal project considered the practicability of placing regulating weirs, for controlling the height of Lake Nicaragua, in what is known as the San Carlos Ridge?

It has been represented that this ridge, for an approximate distance of 5 miles, has depressions below the desired elevation of Lake Nicaragua. A weir or weirs in this ridge, capable of passing 200 000 cu ft. of water per second would probably carry the San Carlos sand out of the canal. Nor is there any apparent reason why, with a high-level canal, the waters of the San Francisco could not be passed through the same weir.

Mr. Haupt. L. M. HAUPT, M. Am. Soc. C. E. (by letter).—Although the issue as to the relative importance of the two routes is at present of minor importance, there are certain statements of fact in this paper which seem to be worthy of further discussion.

For example, the author states as follows:

First.—"The majority of this sand, but not all, comes from the Colorado mouth of the San Juan, and is transported westward by wave action along the beach, on which the waves strike diagonally, under the influence of the prevailing easterly winds."

In the following paragraph it is stated:

"The conditions at the mouth of the Colorado are quite different, and present a nearly stable equilibrium. * * * There has been no appreciable change, up to the present time, at the Colorado mouth, while great changes have taken place at Greytown, * * * The whole geological and physical evidence of this locality points conclusively to the fact that the whole littoral, from the highlands at the mouth of the Colorado to the present canal mouth, is in a condition of constant accretion."

The writer cannot concur with the author as to the interpretation of the physical changes, or their causes, along this portion of that

Mr. Haupt. coast, for they seem to be contradictory, and do not appear to conform to the recorded facts. If the greater part of the sand comes from the mouth of the Colorado, it would seem reasonable to find an extended, protruding bar; and, if the conditions are in stable equilibrium, it is difficult to understand how this locality can be in a condition of "constant accretion," or how the northeasterly trades can drive this sand to the bight of the coast and close the former harbor, when the general trend of the coast at the mouth is nearly south, as may be seen from the map, Plate XXXVIII.*

Moreover, the long and narrow lagoons to the northward of the mouth are very suggestive as to the outlet having been, at no very remote date, some 8 miles farther north than it is to-day.

The following extract from the writer's diary would seem to confirm the thought that the littoral drift does not travel from the mouth northward in the face of the winds, but from the salient southward:

"Thurs. Jan. 6th, 1898.—Inspection of beach to Rio Tauro. Breakers discolored for 300 to 400 ft. out, where they begin breaking, probably in 12-ft. depths. Old, large trees of hardwood standing in and on edge of breakers. Have been there about 20 years, according to our guide. (Some white mangroves were 17 ft. in circumference.) Reached the mouth of the Tauro from Harbor Head Lagoon at 3.10 P. M., and found it had shifted ½ mile south of its position on former maps, and, although the sea was breaking normally to the coast, the creepers and drift were inclined to the southward. Frequent outcrops of hard clay protruded into the breakers, showing active erosion, and accounting for the discoloration. The beach formed a rampart about 6 ft. above low water, and its inner slope terminated in a swamp covered with Silico palms."

The clay *in situ* and the trees of more than a century old standing in the water indicated to the writer that there was erosion rather than "constant accretion," and this view is further confirmed by the comparative study of the charts, for, on January 1st, the diary records that the average recession of the beach at and near the salient east of Harbor Head Lagoon is found to be at the rate of 30 ft. per annum, while, in the bight to the westward, and south of the Rio Indio, there has been an advance of 46 ft. per annum. Between these localities of "cut" and "fill" there is such a neutral axis as the Board of 1895 mentioned in their report, but it is several miles west of the point stated in that report, and only a short distance east of the 1 000-ft. pier built by the Maritime Canal Company. This pier was quite successful in arresting the westward-moving drift and in advancing the foreshore for several miles to the eastward, while that to the westward has receded.

Second.—The author concludes, from the premises, as interpreted, that it is utterly impossible to restore the harbor; and he endorses the location of the entrance at the salient east of Harbor Head, because of the more stable conditions.

* *Proceedings*, Am. Soc. C. E., for October, 1902.

Mr. Haupt.

An examination of all the available charts from 1832 to date, while on the spot, and a critical analysis and study of the movements of the sandy cordon which finally enclosed Greytown Harbor, have been made by the writer. From these data it was found that the average rate of progression of the point was 291 ft. per annum, and the average quantity of material deposited was 582 000 cu. yds. per annum. "At the same rate, to close the harbor would require 9 000 divided by 291, or 31 years—which, added to 1834, gives 1865, at which date it actually closed."

The capacity of the beach to impound the drift, if a jetty were built out 1 000 ft. east of the present structure and extended 3 300 ft. to the 7-fathom contour, would be 16 600 000 cu. yds., and it would require 29 years to fill it. After this, because of the steeper slope and longer reach, the annual advance of the shore line would not exceed 24 linear feet.

From these studies, the writer concluded that the problem of restoring an excellent harbor was quite practicable and relatively inexpensive. The remarkable series of interior lagoons, lying, as they do, to the west of the river, with their axes nearly parallel to one another and at intervals varying from 3 000 to 3 750 ft. apart, demonstrates the cyclic character of the movement due to the constancy of the prevailing forces, and serves to simplify this problem.

In his report thereon, Professor Henry Mitchell, late of the United States Coast Survey, said:

"The rate of advance will be reduced from year to year, because the base of the triangle will extend farther and farther eastward. * * * The examination * * * has satisfied me that a reconstruction of the harbor is practicable."

His estimate of the average annual drift, based on a shorter period, was 730 000 cu. yds., or more than it is at the present time.

The Isthmian Canal Commission believes the harbor can be created at Greytown for a much smaller sum than at Colon, and has thus reported It has located the proposed entrance to the westward of Harbor Head, as being better than the mouth of the Colorado, and the former has the additional advantage of avoiding the severe freshets and the sediment from the large rivers on the Costa Rica bank of the the San Juan.

The availability of this southerly route, of necessity, must depend upon its accessibility from the sea, and, if it be true that the "majority of the sand" (if not all) "comes from the Colorado," and two jetties would be required, aided by dredging, to maintain an opening of sufficient depth, it would seem to present a less favorable condition than the point selected by the Commission.

The survey from which the hydrography has been compiled appears to be that made by the Nicaragua Canal Commission, and it shows the

Mr. Haupt. direction and intensity of the littoral currents off the mouth of the Colorado to be 0.3 and 0.34 knot per hour, setting to the southward. As this is important in the consideration of the direction of the drift, it should not be omitted from the available data.

Until the question of route is determined finally by the Government it would seem to be superfluous to consider further the details of this interesting and important subject.

Mr. Paschke. THEODORE PASCHKE, M. Am. Soc. C. E. (by letter).—The author has advanced a new idea in the construction of rock-fill dams. The writer considers the idea of a steel-chain net, in connection with the construction of a rock-fill dam, a step in the right direction, and analogous to the progressive practice of steel and concrete construction in other branches.

Where is the engineer of practical field experience, who, under certain conditions, has found it not to his convenience to use the sand bag; under certain other conditions, the gabion; and, under still different conditions, the timber or log crib for the retention of loose rock? And is the evolution from the latter to the steel-chain net, or bag, such an irrational one?

It seems to the writer that it is perfectly rational, and he concedes most readily any credit due to the author for the novelty thereof.

However, the writer takes serious exceptions to the dependence placed by the author on the steel-chain net for keeping the rock-fill in place permanently in an overflow dam. The writer is very much afraid that all the author's fine calculations would come to naught during an overflow 15 ft. deep, as he has assumed, over such a dam.

But there are other plentiful opportunities, in the large field of our profession, where the engineer, confronted with certain conditions and problems, would hail this idea of steel-chain bags as a godsend.

For instance, without leaving the field of Isthmian Canal engineering, we need only turn to the problem of temporary dams, as presented by that "old master" of engineering, G. S. Morison, Past-President, Am. Soc. C. E., in his paper on the Bohio Dam, recently discussed by this Society, or for that matter to the very rock-fill dams proposed by him. This would do away entirely with the temporary dam, in his case, which latter dam seemed to perturb him not a little.

In other words, the writer contends that, in the construction of rock-fill dams not designed to take an overflow, the use of the steel chain proposed by the author, in net or bag form, as a guard against sudden floods during their construction is entirely feasible and practical, provided the period of construction is not prolonged beyond a few seasons.

The old adage, which is so well exemplified here in our own blessed country and symbolized on our coat of arms, *viz:* "In Union there is Strength," is the underlying principle of the idea advanced by the author; and who will gainsay it?

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PAPERS AND DISCUSSIONS.

VIRTUAL GRADES FOR FREIGHT TRAINS.

Discussion.*

By Messrs. B. S. RANDOLPH, S. MAXIMOFF and JOHN A. FULTON.

B. S. RANDOLPH, M. Am. Soc. C. E. (by letter).—There is another factor affecting the question of "momentum grades," which Mr. Dennis does not appear to have mentioned: This consists in the surplus energy stored in the boiler after a level or down-hill run, where the use of steam has been for some time less than the boiler production. Mr. Randolph.

No locomotive has yet been built which can supply steam for an indefinite period as fast as it can be used in the cylinders, even at an economical speed; but, by virtue of this stored energy, when the steam is at full boiler pressure, a locomotive can haul a much greater load than can be hauled continuously. In ascending a long grade, a point will be reached beyond which the possible load will depend entirely on the capacity of the boiler to produce steam for current use.

The distance of this point from the foot of the grade will be a function of the momentum and this stored energy.

For all grades having a length less than this distance it would be possible, therefore, to increase the rate, and, by making a corresponding decrease in the length, not affect the maximum load. Attention is called to a practical application of this in Mr. Dennis' paper.

To any engineer of experience in the location of railways numerous examples will occur where such an arrangement will result in no small saving in construction costs.

* This discussion (of the paper by A. C. Dennis, M. Am. Soc. C. E., printed in *Proceedings* for November, 1902), is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.
Communications on this subject received prior to January 23d, 1903, will be published subsequently.

Mr. Randolph. Some years ago, when connected with railway construction, the writer began the collection of data bearing on this subject, with the view of developing some facts of practical value. Subsequent engagements in an entirely different direction prevented further work on this line, but it has always seemed to be a field for investigation of no small value in the economic construction of railways. This paper would appear to furnish valuable data for such a study.

Mr. Maximoff. S. MAXIMOFF,* Esq.—The subject to which attention is called by Mr. Dennis' paper is very interesting indeed; and yet it is true that it has never been discussed sufficiently.

As questions of the same kind are arising in Russia from time to time, the speaker's intention is to give some general idea as to what is being done there, as far as he is able to do so, not being in possession of exact figures.

Fixing grades is one of the most delicate operations in the problem of location of railroads, and, practically, it has to be revised every time that the increase in traffic makes it necessary to undertake further developments. It is not doubted that the proper location of momentum grades would greatly improve existing conditions, and this should always be considered in the first installation.

The speaker does not know whether railway engineers really disapprove of momentum grades. He believes, on the contrary, that they always introduce them, when the possibility of reducing the first cost of installation is clear; but in some cases their adoption involves an extra expenditure in construction, and one should be certain that the traffic will be large enough to justify it.

In some cases the difficulty of introducing momentum grades reaches the impossible. The location of bridges and other railway constructions is often unchangeable; and the necessity for protecting the line from snow exercises a very peculiar influence on the profile of the road. Shallow excavations are regarded as the most dangerous in this respect, and, in Russia, the recent practice in such cases has been to make the excavation like an embankment, which means, that the excavation on one side of the track is deepened considerably and enlarged, and the roadbed looks somewhat higher than other parts of the excavation, as on the new lines of the Moscow-Riazan-Kazan Railroad, for example.

Sometimes, also, a curved transition in vertical plane from one grade to another is used, which is also favorably reported as modifying the shock in the angle.

The difference of level between two divisional points can generally be varied only within small limits, and the author himself thinks that the grades out of a divisional point should be reduced to a somewhat lower grade than at other points.

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* Engineer of Ways of Communication, St. Petersburg, Russia.

Now, the grades, curvatures and other technical features of every new railroad in Russia must be approved by the Government; that is what is called the "technical conditions" and is always printed. Mr. Maximoff.

The same is required for every further development, and the sets of technical conditions furnish the most valuable material for the study of the history and present state of railway engineering in Russia.

In flat country the steepest grades only exceptionally exceed 1%, and one of the oldest and best equipped roads, namely, the Vladikavkas Railway, found it advantageous to rebuild its main line, while reducing the highest grade to 0.6%, at an expense of some $15 000 000.

The distance between the stations very seldom exceeds 20 miles, for the purpose of providing water supply for the locomotives; and, after some years, it is invariably reduced by opening intermediate stop and crossing points; and, usually, level grades, or grades not exceeding 0.2%, for further location of stations, are provided within every 5 to 10 miles, of course, on a sufficient length of track.

Even in the distance of 5 miles there is good reason to take care of momentum grades, but frequent stops change very substantially the conditions of riding, and the stations occupy a very large percentage of the whole length of the line.

Add, too, that the organization of movement of trains on Russian railroads differs very materially from the practice in this country.

The freight trains are not always composed of the full number of cars, and their later arrival is regarded as less important if it does not disturb the movement of passenger trains.

The largest number of cars now admitted in one train is nearly seventy empty cars, and the length of the main track varies between 2 000 and 2 300 ft. on small crossing stations. Thus the desire to increase the number of cars in the train involves an extra expenditure on the stations and increases the difficulty of handling, maintaining and inspecting them. On the other hand, it is practically restricted by the strength of coupling accommodations.

The number of cars at the disposal of each railroad in Russia, Government or private, is regulated by the Government according to the demands of the daily traffic, and every car can be run on every track of the Empire, except on a few railways of small gauge.

The commercial side of this mutual exchange is regulated by reasonable laws. That state of things has great advantages, and the troubles on the grain-carrying railroads of the South of Russia were diminished considerably after its adoption; but it has also some inconveniences, because all substantial improvements of the rolling stock must be undertaken almost simultaneously.

In a very few cases the introduction of momentum grades would lead to increasing the speed at the foot of those grades, and thus necessitate the adoption of heavier types of rails, thus involving additional expense or a great variety of types of rails.

Mr. Maximoff. Another unfavorable circumstance is that the elevation of the rails on curves is always adapted to quick-moving passenger trains, and the wheels of the cars of a heavy freight train, by want of centrifugal force, are pressed against the interior rail, thus increasing the resistance. In the technical conditions it is mentioned that the resistance of a train moving on a grade on a curve must be the same as on the highest grade without curvature; that means that in curvature the grades must be reduced; but it is very difficult to ascertain whether in practice this rule is followed carefully, and, even if the passenger trains move under good conditions, the freight trains may be somewhat neglected in such respect.

Thus, many different circumstances, *pro* and *contra*, fight the introduction of momentum grades, and, in fact, all their theoretical advantages may be destroyed by some intractability on the part of the engineering *personnel*, or may become of minor importance in the presence of other urgent improvements of a commercial nature; but still the speaker fully agrees with the author that the lack of good experiments leads to lack of attention to this subject.

In Russia the calculation of virtual grades is generally made by using the formula of General Petroff, whose remarkable studies on the friction and on the resistance of trains are printed in Russian and French, and are thus accessible to American engineers. Further developments are necessary, however.

To make good experiments is a difficult task; and great faults are often committed by very able men, especially in the determination of the grade, which always needs the most precise leveling.

During construction the grades are often executed by the contractors, and not exactly in accordance with the drawings. Even in the maintenance of the railroad, considerable changes may occur by the renewal of ballast. For example, the speaker once was told that a certain station, after some few years of existence, instead of being on a level grade, was found to be on a 0.3% grade. If the greatest precautions for an exact determination of the grade be not taken, the results of experiments may become entirely wrong.

The conditions of the roadbed, whether frozen or not, that is, whether more or less elastic, are also to be examined carefully, and the latest practice is to use the photographic method of observation, as developed by Mr. Vassiontynski, Engineer of Ways of Communication.

For eliminating, as far as possible, the influence of the personal ability of the engineer of the train, the apparatus of Mr. Livtsnak was found of great value, showing to the locomotive man the profile of the line, the position of the engine, and its speed at every moment.

Russian rolling stock is somewhat different from American, and the author's conclusions cannot be adapted entirely to the peculiar Russian conditions.

The subject is of great interest and of considerable importance, and is treated very successfully by the author. Mr. Maximoff.

JOHN A. FULTON, M. Am. Soc. C. E. (by letter).—The writer has made some experiments to find out what speeds a specific freight train ought to be able to make, on various rates of grade, with the ultimate object of determining to what extent it is practicable to use momentum grades. Mr. Fulton.

One of the conclusions he arrived at, and which might, perhaps, have been accepted beforehand, is, that every rate of grade has its corresponding normal speed for any specific train, and that every speed has its normal grade for that train.

A train which can maintain a uniform speed of 15 miles per hour on a long + 0.70% grade can maintain a uniform speed of 40 miles per hour on a — 0.20% grade; and if at any moment that train is actually running at a speed of 40 miles per hour, it is virtually running down hill, although the profile grade at that point may be very decidedly up hill.

Another conclusion arrived at is, that momentum already acquired has but a limited field of influence, and cannot be spread out indefinitely over a long, steep grade.

A train running from *A* to *B*, 5 or 6 miles distant, starting from a state of rest at *A*, and working steam continuously, will have substantially the same speed at *B* as if it had left *A* with a high speed, of, say, 40 miles per hour.

The writer's diagram, Fig. 7, for a + 0.40% ruling grade, is based on the assumption that the combination of engine and train will be such that it can maintain continuously a speed of 10 miles per hour on a + 0.40% grade of unlimited length.

This is a somewhat lighter load, assuming the same engine for each, than one which could make only 7 miles per hour on a + 0.40% grade, which the author has assumed.

On comparing the performances of the train, as indicated by the author's diagram, with those of the lighter train, by the writer's diagram, it will be seen that this lighter train does not acquire quite as high speeds in a given distance, and loses speed more quickly on an adverse grade.

These differences are generally slight, but, in some cases, as on a + 0.10% grade and with an initial speed of 30 miles per hour, the resulting speed at the end of one mile of such + 0.10% grade would be 29 miles per hour, according to the author's diagram, while, according to the writer's diagram, this engine hauling a lighter train would have a speed of only 25 miles per hour.

On comparing the author's and the writer's diagrams, for + 0.50% and + 0.60% ruling grades, similar differences appear.

It may be said, therefore, that the writer's diagrams, adapted best to

Mr. Fulton. engines having about 56-in. drivers, give results a little more conservative than those of the author.

The author notes a considerable drop in steam power after passing the first mile, indicating that his train is too heavy even for the 7-mile continuous speed on a + 0.40% grade, and that the apparent differences between the results on the two diagrams are not quite as great as the actual differences.

It is probable that these differences are largely due to the widely different values ascribed to train resistance.

It seems incredible that train resistance can be substantially a constant quantity for all freight-train speeds.

If that were true, then a freight train, having an initial speed of, say, 40 miles per hour when commencing the descent of a — 0.30% grade (the author's 4.7 lbs. per ton is the equivalent of a + 0.23% grade), would continue to increase in speed indefinitely, and would "run away" even with steam shut off.

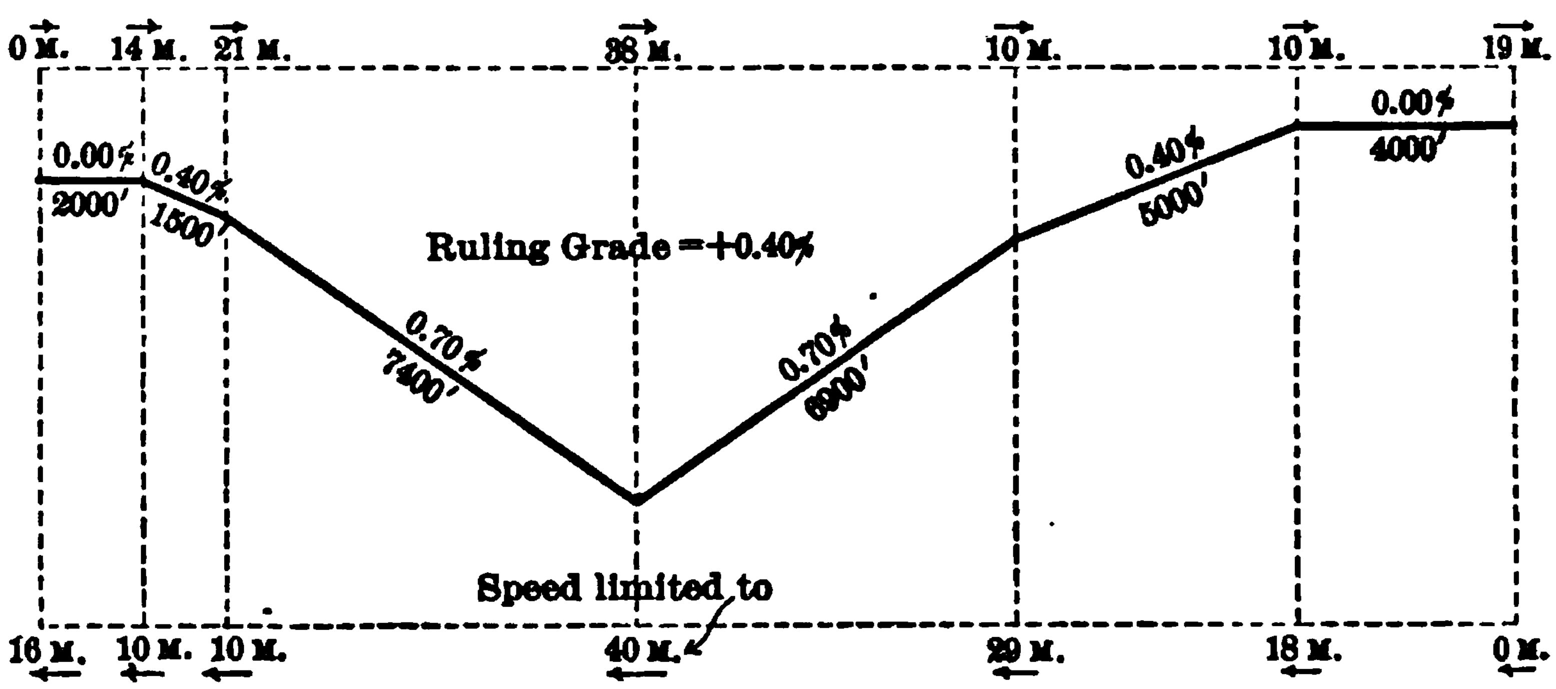


Fig. 6.

According to the writer's method, this train, adapted, as noted, for a + 0.40% ruling grade, would slow down to about 36 miles per hour even when working steam to the best advantage; and, if not working steam, but running by gravity alone, it would slow down to 16 miles per hour, for the reason that the train resistance at this latter speed would be about 6 lbs. per ton, or equivalent to a + 0.30% grade.

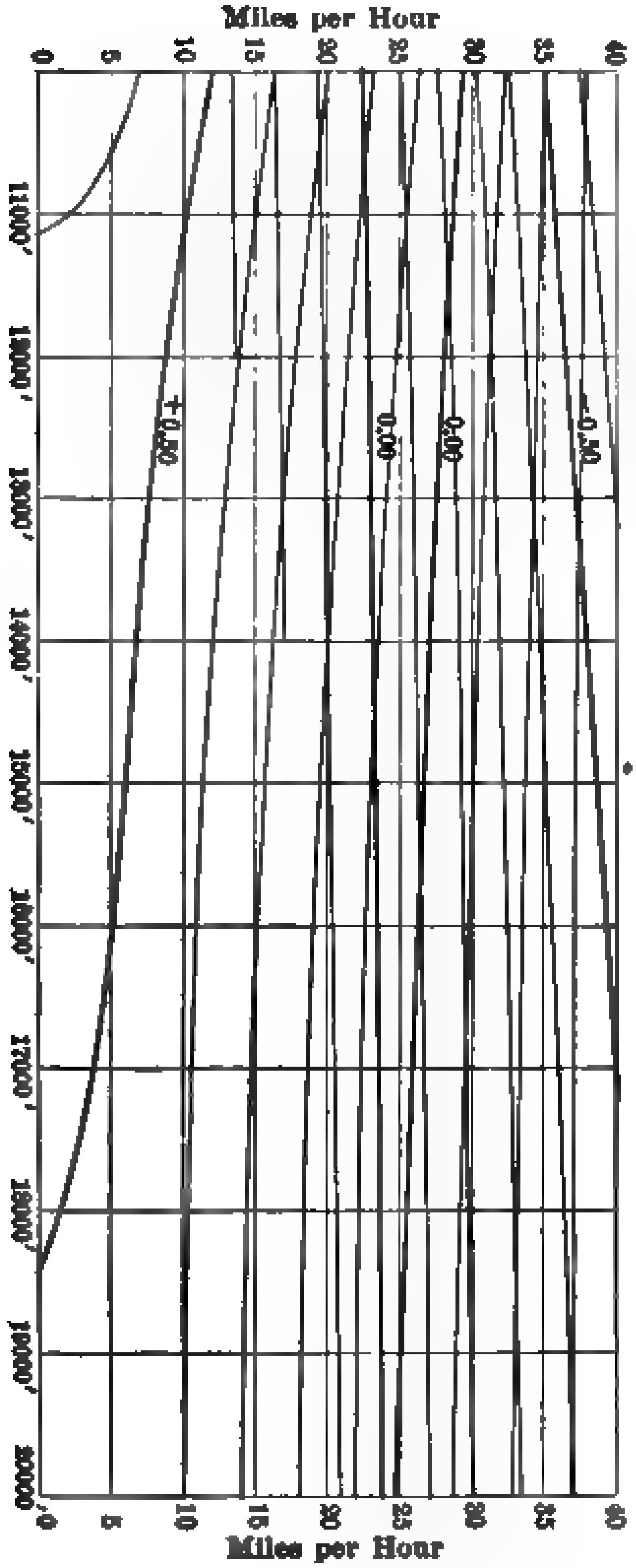
Mr. Wellington's experiments in "coasting" down a —0.70% grade coincide almost exactly with the values determined from the *Engineering News'* formula for train resistance ($R = 2 + \frac{V}{4}$); and it seems probable that this formula is close enough for all practical purposes.

The method of using the diagram will be understood from the sketch, Fig. 6, and may be described as follows:

Select the initial speed on the curved line representing the grade in question; follow that curve a distance equal to the grade length, and

Mr. Fulton.

TRAIN SPEEDS AND DISTANCES CORRESPONDING WITH TEN-MILE MAXIMUM CONTINUOUS SPEED ON +0.40% GRADE.



Miles per Hour

FIG. 7.

Mr. Fulton. read the speed at that point; with that speed on the curve representing the next grade follow along that curve, as on the former curve, and read the speed as before.

The sketch, Fig. 6, shows how it is sometimes possible to build a piece of railroad on apparent 0.70% ruling grades, and then operate it as on 0.40% ruling grades.

MEMOIRS OF DECEASED MEMBERS.

NOTE.—Memoirs will be reproduced in the Volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Secretary prior to the final publication.

GEORGE SEARS GREENE,* Past-President and Hon. M. Am. Soc. C. E.

DIED JANUARY 28TH, 1899.

George Sears Greene, son of Caleb and Sarah Robinson Greene, was born at Apponaug, in the Town of Warwick, Rhode Island, on May 6th, 1801.

He was a descendant, in the seventh generation, from John Greene, a surgeon, who came to America in 1635, from Salisbury, England, and settled in Warwick in 1642. Among his descendants, in the fifth generation, was General Nathanael Greene, who was a distinguished officer in the American Army in the War for Independence.

The subject of this memoir entered the United States Military Academy at West Point in 1819. During the last year of his academic course he was Acting Assistant Professor of Mathematics. In June, 1823, he was graduated second in his class, was appointed Second Lieutenant of Artillery, and was detailed as Assistant Professor of Mathematics and Engineering in the Academy, and continued there until 1827, with the exception of four months' service in the Artillery School at Fortress Monroe in 1824. On leaving West Point he served with his regiment, the Third Artillery, on garrison duty in Maine, Rhode Island and Massachusetts, and on ordnance duty.

In May, 1829, he was promoted to a First Lieutenancy. On June 30th, 1836, he resigned his commission in the Army and entered on the practice of civil engineering, engaging in the construction of railroads in North Carolina, Maine, Massachusetts, Rhode Island and Maryland.

In 1856 he was retained by the Croton Aqueduct Department of New York City, and for six years was occupied in the design and construction of works for the extension of the water supply, comprising the large distributing reservoir in Central Park, 38 ft. deep, and covering 96 acres; the construction of a wrought-iron pipe, 90.5 ins. in diameter and 1 400 ft. long, on High Bridge, across the Harlem River; and the laying of a cast-iron pipe, 60 ins. in diameter and 4 116 ft. long, across Manhattan Valley.

There were at that time no examples of similar works of equal magnitude with these. The plans and specifications prepared for

* Memoir prepared by J. James R. Croes, L. L. Buck and G. S. Greene, Jr., Members, Am. Soc. C. E., Committee appointed by the Board of Direction.

these works by Captain Greene were carefully elaborated, and embodied several novel features in reservoir and pipe construction, among which were the precautions taken against leakage and loss of water by founding the puddle walls in the surrounding embankments on concrete laid in trenches in the solid rock; by constructing a division embankment, with its top 3 ft. below the full water line of the reservoir, and having in its center a puddle wall founded on concrete resting on rock, and having upon it a toothing wall of brick masonry, 4 ft. high, which the puddle embraced; by lining the water faces of all embankments with a pavement of masonry on a bed of concrete; and by requiring all embankments to be built up in thin layers rolled with a grooved roller.

Another novel practice was the use of concrete in large masses (rendered practicable by the invention of the stone crusher in 1858 by Eli Whitney Blake), and the reduction of cost and increase of specific gravity of the mass by the insertion of large unwrought stones. There was also no precedent for the construction of the 90-in. wrought-iron pipe across High Bridge, more than ¼ mile long supported on saddles which rest on rollers, thus permitting changes in length caused by variations in temperature to be taken up by a stuffing box at each end of the pipe.

In the case of the pipe across Manhattan Valley, which was of 12 ins. greater diameter than any cast-iron water pipe previously manufactured, Captain Greene's investigations, of the material and methods of manufacture then existing, led him to discard the ordinary hub joint and to have the pipes cast as straight cylinders, with the joints made by half-sleeves bolted together. No leaks or fractures have occurred in these pipes, while, in the case of a line of 6-ft. cast-iron pipe with hub joints, laid some years later, under other auspices, most of the joints failed under pressure when water was turned on.

The works which Captain Greene had designed were well under way when the attempt was made to destroy the integrity of the Union. He responded promptly to his country's call, and went to the front in January, 1862, as Colonel of the 60th Regiment, New York Volunteers. On April 8th, 1862, he was commissioned as Brigadier General, United States Volunteers, and served in the Army of Northern Virginia and the Army of the Potomac until September, 1863, participating in the battles of Cedar Mountain, Antietam, Chancellorsville, numerous minor engagements, and Gettysburg, where, on the night of July 2d, 1863, his brigade, reduced to less than 1 500 men, held the extreme right of the Federal line on Culp's Hill for four hours against repeated assaults of the enemy, and defeated the strenuous efforts made to turn the Federal flank. In October, 1863, his brigade accompanied the Twelfth Army Corps to Tennessee, where he participated in several engagements, until October 28th, when, at the battle of

Wauhatchie, a Minie rifle bullet passed through his mouth, coming out through his right cheek. Even this severe wound only disabled him temporarily, thanks to his vigorous constitution and determined will. He did not even go into hospital, and in forty days was able to perform court-martial duty, to which he was assigned and on which he served until January 25th, 1865, when he rejoined his brigade in the field in North Carolina and took part in numerous minor engagements. On March 13th, 1865, he was commissioned as Brevet Major General, United States Volunteers, for "gallant and meritorious services." He served on garrison and court-martial duty in Washington, D. C., until April 30th, 1866, when he was mustered out of the service. This terminated General Greene's military career, except that in 1894 Congress passed a special act restoring him to the Regular Army, with the rank of First Lieutenant, and retiring him.

In civil engineering, however, it was only the beginning of another twenty years of active practice, at an age when most members of the profession are considering retirement from practice.

The Croton Aqueduct Department of New York City had just reached the determination to construct additional storage reservoirs in the Croton Valley, and, after a year spent in careful examination and comparison of several sites, the availability of which had been made apparent by a comprehensive survey of the entire valley made several years before, had decided, on March 17th, 1866, to construct the first of such reservoirs at Boyd's Corners, on the West Branch of the Croton River, where it was found that a dam, 78 ft. high from bedrock and 670 ft. long at top could be built to impound 2 700 million gallons. Of the design and construction of this work, General Greene took charge on May 1st, 1866. There were no American precedents for the construction of dams of this magnitude, and there was no literature on the subject in the English language. Indeed, the only published discussion of the principles which should prevail in the design of high masonry dams was the treatise of Sazilly in the *Annales des Ponts et Chaussées*, in 1853. But, with General Greene's thorough scientific education, his long experience with materials and modes of construction, and his habits of prompt decision, accentuated, no doubt, by his recent active participation in military affairs, it did not take him long to decide upon a plan of dam in which the materials most available should be utilized, with the least expenditure of time and money, and so disposed as to produce the most effective results; and on August 28th the contract was let for the construction of the Boyd's Corners Dam.

On May 11th, 1867, on the retirement of the late Alfred W. Craven, Past-President, Am. Soc. C. E., from the position of Commissioner and Chief Engineer of the Croton Aqueduct Department, General Greene was chosen as his successor, and held that position until the

Department was abolished by the charter of 1870, and its duties transferred to the Department of Public Works, on May 1st, of that year. General Greene remained in the service of the Department until January 11th, 1871, as an assistant engineer.

From 1868 to 1871 he was also Consulting Engineer to the Morrisania Survey Commission which inaugurated the system of exact topographical surveys and monumenting of base lines and of street lines which has since been extended over the whole of what is now termed the Borough of the Bronx, under the specifications framed by the engineers to this Commission. On August 24th, 1871, he was appointed Chief Engineer of the newly organized Board of Public Works of the District of Columbia, with instructions to devise a system of sewerage for the City of Washington. He made a report on this subject, but his connection with the works terminated on June 24th, 1872, and he returned to New York, and, from October, 1872, to September, 1873, was Consulting Engineer, to the Department of Public Parks, on communications across the Harlem River by bridges and tunnels.

In the year 1873 he was also occupied as one of a Board of Engineers to examine the surveys and estimate the cost of a ship canal from Lake Champlain to the St. Lawrence River; and as a member of an Engineer Commission to test the working and construction of water meters for New York City. He was also called upon to examine projects for extending and improving the water supply of Detroit, and on August, 15th, 1874, in conjunction with his colleague in the investigation, General Godfrey Weitzel, reported that filtration was necessary to ensure purity in the water drawn from either Lake St. Clair or the Detroit River. This suggestion was too far in advance of the times to be regarded favorably by the authorities.

On June 1st, 1874, he was appointed Civil and Topographical Engineer to the Department of Public Parks of New York City, in charge of the designing of the street system for the then recently annexed district north of the Harlem River, now designated the Borough of the Bronx. Some studies of plans for streets were made by him, but on November 5th, 1875, he was transferred to the position of Engineer of Construction of Streets and Sewers, in that District, which office he held until October 3d, 1877. The most important of the works of which he had charge during this period was the main outfall sewer of Brook Avenue, which drains an area of 2 615 acres and has a gradient of only 1 ft. in 2 618 ft. It is an arched conduit of brick, 12 ft. wide and 9.88 ft. high, the bottom being below the water level in the Harlem River, into which it discharges. The specifications for this work were very complete and thorough, and were deemed worthy of preservation, as an example of

what such a document ought to be, in the American reprint of Baldwin Latham's book on Sewerage, issued in 1877.

In the consideration of the question of rapid transit in New York City, between 1866 and 1880, General Greene took an important part. The Legislature of 1866 designated Mr. A. W. Craven, the engineer of the Croton Aqueduct Board, as one of the members of a Commission to report upon the most advantageous and proper routes for the transportation of passengers in New York City; and the task of examining critically the numerous suggestions made to that Commission devolved largely upon General Greene, Mr. Craven's associate in this work. The conclusion reached by the Commission was that the best method of attaining the desired end was by the construction of underground railways. The New York City Central Underground Railway Company was incorporated in 1869, and at once caused examinations of its proposed routes to be made by W. W. Evans, E. S. Chesbrough and General Greene, and their report, estimating the cost of the road from City Hall Park to Harlem River at $17 625 301, and expressing the opinion that "the work in question will pay," was presented on October 19th, 1869. Capital could not be procured to carry out these plans. In 1871 General Greene, as consulting engineer to the Beach Pneumatic Railway Company, advocated the construction of a railroad under Broadway. When underground roads were found to be impracticable for the time, he was engaged in 1873 to consider the plans for the construction of the Greenwich Street elevated railway from Rector Street to Thirtieth Street. Six years later, when the extension of the elevated railroad system was agitated, he was appointed engineer to the Rapid Transit Commission of April 2d, 1879, which established the route and prepared the plans for the crossing of the Harlem River at Eighth Avenue and 155th Street, and organized the West Side and Yonkers Rapid Transit Company, which built the bridge there. This Commission also organized companies and had plans and specifications prepared for a rapid transit railroad from the City Hall to Forty-second Street, and for several new lines of road in the Borough of the Bronx, but the Courts decided that their powers had been exhausted by the organization of one company.

Of the hydraulic and sanitary works on which, at about this period, General Greene's opinion was sought, may be mentioned the water supply for Yonkers, New York, in 1874; projects for the sewerage of Providence, Rhode Island, in 1875; and the enlargement of the water-works of Troy, New York, in 1877. In 1883 he was one of the engineers called upon by the Commissioner of Public Works of New York City to advise upon the plans prepared for the New Croton Aqueduct.

On March 6th, 1886, he was appointed by the Aqueduct Commissioners as one of a Board of Examining Engineers to investigate

charges which had been made affecting the management and the condition of the work which had been done. Such was his physical vigor even at his advanced age that he insisted on walking through the entire length of the tunnels, examining closely everything as he went, a task to which his associates, Generals Newton and Gillmore, found themselves unequal, although nearly twenty-five years his juniors. This was his last professional service, but he maintained his mental vigor and much of his physical strength until his death, which occurred on January 28th, 1899, at his home in Morristown, New Jersey.

In his whole career as a civil engineer, General Greene, while cautious and conservative, was progressive, and kept fully abreast of all advances in his profession. He was one of the original members of the American Society of Civil Engineers, established November 5th, 1852, was President of the Society for two years beginning November 3d, 1875, and was elected an Honorary Member on October 26th, 1888.

In social life he was fond of companionship, and was greatly beloved by a large circle of friends of all ages to whom the stores of information acquired in his long career of close study and acute observation, and preserved in his remarkably retentive memory, were freely unfolded. An enthusiastic member of the Military Order of The Loyal Legion, the reunions of that association were a source of great enjoyment to him as well as to his old comrades. He esteemed particularly the hereditary feature of the organization, taking, as he did, great interest in genealogical studies. He was, for several years, President of the New York Genealogical and Biographical Society. He was, also, for thirty-one years, a member of the Century Association of New York City.

On July 14th, 1828, he was married to Elizabeth, daughter of David and Mary (Atwell) Vinton, of Providence, Rhode Island. She died on December 26th, 1832. On February 21st, 1837, he married Martha, daughter of Samuel Dana, of Charlestown, Massachusetts, for many years a Representative in Congress. Five sons and a daughter were the offspring of this marriage.

SAMUEL BARRETT CUSHING,* M. Am. Soc. C. E.

DIED DECEMBER 2D, 1888.

Samuel Barrett Cushing, Junior, was born in Providence, Rhode Island, on July 21st, 1846, and was the son of a Member of the

* Memoir prepared by the Secretary from information furnished by Edwin P. Dawley and George C. Tingley, Members, Am. Soc. C. E., and W. C. Simmons, Esq.

American Society of Civil Engineers who was considered among the first of the hydraulic engineers of his day.* Young Cushing's early education was obtained in the public schools of Providence, and in May, 1866, on being graduated from the High School, he entered his father's office. On the death of his father, in 1873, Mr. Cushing succeeded to the business. His ability was recognized by the Supreme Court of the State, which appointed him to succeed his father, and gave him authority to regulate the taking and use for power of the water of the Blackstone River at Pawtucket and Woonsocket, under the decree based upon his father's investigations and report.

The rearrangement of the railroad terminal facilities in Providence, recently accomplished, a matter in which the municipality and the railway corporations were jointly concerned, was for many years a subject for consideration and report by various commissions. The elder Cushing was engineer to one of the earlier of these bodies, the Commissioners of the Cove Lands, which presented its report in 1873, but, as he was in feeble health when the engineering work was done, the plans submitted by this commission were those of the son. Another work of consequence in the elder Cushing's charge at the time of his death was the building of the dam of the Flat River Reservoir, which flowed an area of 900 acres, and this work the young man carried to completion.

In railroad work, Mr. Cushing made preliminary surveys for a line from Ashland to Lowell, Massachusetts, passing through Framingham, Wayland and Concord, also a line from Northbridge to Milford, Massachusetts, and made the preliminary survey and located the Webster Branch of the Boston and Albany Railroad, from Webster to Rochdale, Massachusetts. He was the local engineer at Providence of the Boston and Providence and the Providence and Worcester Railroads, and constructed the East Providence Branch of the latter road, from Valley Falls to tidewater in East Providence.

Much of his practice was devoted to foundations. He built the Arkwright Dam, the Blackstone Dam, the Barden Reservoir Dam and the Happy Hollow Dam, and was Consulting Engineer on the construction of the dam of the Diamond Hill Reservoir for the Pawtucket Water-Works. On the construction of these works, he was appointed by the Court, as Commissioner, to Award Damages to the Mill Owners of Pawtucket and Central Falls for water taken from the Abbott Run by the water-works.

He was considered by the Town of Cumberland, Rhode Island, as its engineer, and designed and built several highway bridges over the Blackstone in that town. Six bridges over the Abbott Run, a tributary of the Blackstone, were also built by him. Among the larger single pieces of work he undertook were the coal pockets on the Lons-

* For Memoir of Samuel Barrett Cushing, Senior, see *Proceedings*, Am. Soc. C. E., Vol. 1, p. 48.

dale Company's wharf at Providence, and the foundations for the large chimney of the Narragansett Electric Lighting Company in Providence,* on which he was engaged at the time of his death. He was of quiet and gentlemanly tastes and was highly esteemed by those with whom he was associated.

Some of the Members of the American Society of Civil Engineers commenced their careers in the office of the Messrs. Cushing, among them being Messrs. Elmer L. Corthell, Desmond FitzGerald, J. Albert Monroe, George C. Tingley, Richard H. Tingley, Henry W. Parkhurst and William H. G. Temple.

Mr. Cushing was elected a Member of the American Society of Civil Engineers on June 1st, 1887.

CHARLES FLETCHER HILLMAN,† M. Am. Soc. C. E.

Died June 14th, 1902.

Charles Fletcher Hillman was born on December 19th, 1835, at Albany, New York, and was educated at the New York State Normal School.

From November, 1853, to February, 1855, he was located at Windsor, Canada West, as Assistant Draftsman to Associate Chief Engineer William Scott, of the Great Western Railway of Canada, and was employed on surveys of the proposed branch from Amherstburg to Baptiste Creek. In 1855 he was Assistant Engineer on the preliminary plans and estimates for the Canada Southern Railway, from Niagara Falls to Detroit, Michigan; and Principal Assistant Engineer on surveys for a proposed harbor at Two Creeks, on the North Shore of Lake Erie. From 1855 to 1857 he was Assistant Engineer on the location and construction of the Detroit and Milwaukee Railway, between Ionia and Grand Haven, Michigan.

In 1857 he accepted an engagement from Mr. Henry Meiggs to work on the "Ferrocarril del Sur," and from that year until 1864 he was Assistant Engineer to the late Anthony Walton Whyte Evans, M. Am. Soc. C. E., on the various State Railways of Chile, being engaged on the surveys and construction of the lines between Santiago and San Fernando, and between Santiago and Valparaiso.

Mr. Hillman was the Contracting Engineer for the Tongoy Railway of Chile in the years 1865 to 1868; and from 1870 to 1876 he was Chief

* *Transactions*, Am. Soc. C. E., Vol. xxv, p. 1.

† Memoir prepared by the Secretary from papers on file at the Society House.

Engineer on the construction of the Palmilla Branch and of the completed portion of the Chile Southern Railway, from Santiago to Curico. In 1871 he undertook the construction of part of the tramcar lines in Valparaiso.

The last railways built by Mr. Hillman, before retiring from active service, were those between Angol and Traiguén and between Renaico and Victoria in 1884. In the construction of these roads he was in partnership with Mr. Stephen Mayers. On account of delays and difficulties caused by the construction of the high bridge over the Malleco, near Collipulli, which was under the charge of the Government Engineer, Mr. Lastarria, the latter section was turned over to the Government before it was fully completed.

On several occasions Mr. Hillman was appointed by the Chilean Government to give information on technical matters, and was always a warm friend of the Chileans, both at home and abroad.

Some years ago Mr. Hillman introduced the manufacture of matches in Chile by the establishment of a factory at Rancagua. This factory was afterward removed to Santiago. During the last years of his life he acted as one of the Directors of the Santiago Gas Company, and to his influence are due the facilities given by the Company for the use of gas in the industries.

Mr. Hillman was one of the most prominent and influential members of the American colony in Santiago. He was a member of the Board of Trustees of Union Church, of the Sunday School, and of various philanthropic and social institutions. On several occasions he delivered lectures on behalf of charitable objects. He contributed to the press a number of articles on important railway problems, several of them being on the relative merits of English and American systems of equipment and rolling stock. Under the pseudonym of "Quien Sabe," he published, in 1901, a volume of some 300 pages, entitled "Old Timers, British and American, in Chile," which is a most valuable contribution to the history of Anglo-American influence in the growth and development of Chile. This work first appeared as a series of articles contributed to *Our Young People*, of which Mr. Hillman was, for several years, one of the Associate Editors.

Mr. Hillman took great interest in the educational work of his church, and not only contributed toward the outfit of the college established in Santiago, but used his influence with others for the same purpose. He took special interest in becoming acquainted with the scholars, individually, and accepted honorary membership in the Alumni Association.

In 1862 Mr. Hillman was married to Miss Caroline Haviland, a daughter of Samuel Frost Haviland, Esq., an American gentleman, resident in Chile. Of the seven children born to them only three remain.

In 1896 and 1897, accompanied by his family, Mr. Hillman made an extended visit to the United States, his first visit since his arrival in Chile. They came by way of San Francisco, and returned by the East, visiting Europe on the way back. During 1901, in company with his wife, he made another trip to the United States to visit his youngest daughter who was here in school. He did not remain long, however, on account of the illness of Mrs. Hillman.

Mr. Hillman was elected a Member of the American Society of Civil Engineers on July 5th, 1876. He was elected a Member of the Institution of Civil Engineers on April 4th, 1882. He was one of the founders of the "Sociedad de Fomento Fabril," was a member of the Council of Directors, and was zealous in the work of that society.

ASHLEY BEMIS TOWER,* M. Am. Soc. C. E.

DIED JULY 8TH, 1901.

Ashley Bemis Tower was born in the Town of Windsor, Massachusetts, on June 26th, 1847, being the youngest son of Stephen D. and Esther E. Tower, and one of a family of ten children.

He was of the eighth generation descended from John Tower, who in 1637, during the religious troubles of that time, came from Hingham, Norfolk County, England, and settled at Hingham, Massachusetts, helping to found that town. Mr. Tower's ancestors on his father's side fought in both King Philip's and the Revolutionary Wars.

Early in 1854 the family moved to Dalton, Massachusetts, where he received a common school education, and, with his father, worked upon the farm. At the age of twenty-one, Mr. Tower went to Newburg, New York, and there learned the carpenter's trade with an older brother.

In 1871 Mr. Tower left Newburg for Holyoke, Massachusetts, to enter the engineering office of another brother, D. H. Tower, where for seven years he studied and labored, preparing himself for the profession which he afterward made his life work.

During the fall of 1878 the brothers became associated under the firm name of D. H. and A. B. Tower, to carry on a business as architects and civil engineers. They were pioneers in the practical design of paper mills, and soon reached an enviable position in that branch of the profession.

During the thirteen years that they were together, a great many of the paper, pulp and fiber mills built in the United States were designed

* Memoir prepared by J. W. Tower, Assoc. M. Am. Soc. C. E.

by them. They also furnished plans for mills erected in Canada, Brazil, Germany, Japan and Australia, and designed several textile mills.

During the years 1884 and 1885, Mr. Tower visited Europe twice in order to study foreign methods of paper-mill construction.

In January, 1892, the partnership was dissolved, and Mr. Tower carried on the business himself until February, 1893, when Mr. George F. Hardy became associated with him under the firm name of A. B. Tower and Company. This arrangement was continued until March, 1896, when Mr. Hardy retired, and again Mr. Tower went on with the work alone.

In 1897, owing to increased business and the necessity for a more central location, the offices were moved from Holyoke to New York City. During October of the same year, the firm became Tower and Wallace, in which Joseph H. Wallace, M. Am. Soc. C. E., was junior member. Mr. Wallace retired in February, 1901, and Mr. Tower remained alone until the time of his death, which occurred very suddenly, at his home in Montclair, New Jersey, on July 8th, 1901.

For a number of years Mr. Tower was Consulting Engineer for the American Sulphite Company, and in 1881 was elected City Engineer of Holyoke, Massachusetts, which position he held for three years.

He was a man of fine physique, standing more than 6 ft. in height, always courteous, modest and frank.

In 1875 he married Miss Pamelia J. Fritts, who survives him. Mr. Tower was elected a Member of the American Society of Civil Engineers on October 3d, 1894; he was also a Member of the American Society of Mechanical Engineers, and of the Canadian Society of Civil Engineers, and was well up in Masonry, being a Knights Templar, and a 32° Mason in the Scottish Rite.

JOHN WOODBRIDGE DAVIS,* Assoc. Am. Soc. C. E.

DIED NOVEMBER 7TH, 1902.

John Woodbridge Davis was the son of Dr. Edwin Hamilton and Lucy Woodbridge Davis. His father, a physician of New York, was Professor of Materia Medica and Therapeutics in the New York Medical College, and was noted also for his investigations and discoveries in the ancient mounds of the Mississippi Valley. His book on the subject was the first published by the Smithsonian Institution. The family stock was a mingling of New England and Southern elements.

* Memoir prepared by J. S. Sewell.

Mr. Davis was born in New York on August 19th, 1854. He received his earlier education at public and private schools in New York and Ohio.

From 1872 to 1874 he was engaged as transitman on the Baltimore and Ohio Railroad. As a student in the School of Mines, Columbia University, Mr. Davis published his "Formulæ for Calculating Railroad Excavation and Embankment" (1876), which was immediately adopted for use as a textbook in the School of Mines and in other Colleges. He had entered the University as a sophomore in 1875. At the same time he was exhibiting literary ability. In October of that year a prize offered for an essay—the contest being open to all students of Columbia—was won by Mr. Davis' essay on "Philosophy," published in *Acta Columbiana*, December, 1875. Previous to that time he had published poems and articles in New York and Ohio newspapers. Now, he became editor of *Acta Columbiana*—1876–1877—and contributed largely thereto. He was graduated with the degree of Civil Engineer in 1878, when he was Class Historian.

From 1879 to 1882 he was in Tennessee, where he surveyed 900 000 acres of land—the domain of the Grundy Mining Company—extending into eleven counties of Tennessee, in the Cumberland Mountains. This position demanded not only ability, but also courage and character, for the mountain squatters and woodsmen were dangerous people who resented curtailment of their self-made privileges. So conspicuous was the success of Mr. Davis in this undertaking that he was offered another civil engineering position under The Tennessee Coal, Iron and Railroad Company. This he declined, through a desire to make his home in New York.

He had secured the degree of Doctor of Philosophy from Columbia in 1880—chiefly by five articles published in *Van Nostrand's Engineering Magazine* in 1879. These were:

"A New Rule for Calculating the Contents of Land Surveys,"

"The Prismoidal Formula,"

"A New Center of Gravity Formula of General Applicability,"

"A New and General Moment of Inertia Formula,"

"A New Graphical Method for Finding the Center of Gravity of a Polygon."

In 1881 he published, in the *School of Mines Quarterly*, "Inaccessible Distances in Surveying"—a paper written in collaboration with Professor Henry S. Munroe.

In 1882 Mr. Davis instituted the Woodbridge Preparatory School, and conducted it with success until 1897. As an educator he approved himself to the public. He had the power of elevating the moral as well as the intellectual standard of his pupils. His personality was winning and his influence great.

In 1883 he contributed a chapter to Davies' "Surveying." In 1884

he was appointed Examiner of Civil Engineers for New York City, in the Municipal Civil Service Examination Board, being the first to hold such a position in this city. Papers descriptive of the Civil Service Examinations appeared in *Engineering News* in 1895.

In 1884 Mr. Davis was one of the Committee of Ten, appointed from the Alumni of the Columbia School of Mines, for the purpose of examining the condition of the school and making beneficial suggestions. The report of the Committee embodied fifty-five recommendations in regard to changes in the curriculum and the standard of admission.

For several years Mr. Davis had spent time in research for the purpose of preparing a "Biographical Chart" designed to present comprehensively the names of those most eminent in any department of the world's effort, some knowledge of whom would be included in a scheme of general culture. The arrangement of the chart gave a clear notion also of the prevailing lines of industry at different periods. It was finished in 1888.

In 1889 he published, in the *School of Mines Quarterly*, under the title "Chronology of the Human Period," an interesting chart exhibiting the principal scales used in the division of prehistoric time in their chronological inter-relation.

His book, "Dynamics of the Sun," was published in 1891. Its importance was recognized by eminent scientists.

In the same year, with John B. Farrington, he secured a patent on an electric motor for statical electricity adapted to the use of students, and to experimental purposes.

In 1892 he perfected his invention of a life-saving kite. The J. W. Davis Foldable Steerable Kite was patented in 1893. Various successful tests of its assumed ability to carry a hawser weighing a ton from a ship to land more than a mile away, in a brisk wind such as blows on shore when vessels are in danger of shipwreck, were made from islands in the East River, across Kill von Kull, and from *Brenton Reef Lightship* to the shore. The trials attracted the attention of newspapers and scientific journals throughout the United States. They were also noticed in English, French and Canadian papers.

In 1894 articles by Mr. Davis on "The Kite as a Life-Saver at Sea," and "Some Experiments with Kites," appeared in *The Engineering Magazine* and in *Aeronautics*.

In 1893 he patented an apparatus for lighting buildings. Models and practical tests promised to be so expensive that Mr. Davis was compelled to defer them. On the completion of other plans, it was his intention to return to this invention, in the practical outcome and high utility of which he had great faith.

In 1895 Mr. Davis secured a copyright on "How to Pronounce the Names that are Liable to be Mispronounced of People and Streets in the Principal Cities of the United States."

The article, "How Translatory Movement may be derived from Vibratory Movement," appeared in the *School of Mines Quarterly* in 1895. A review of "Gillespie's Surveying" was published there in 1896.

Mr. Davis now became anxious to devote more time than the conduct of his school would allow to original research in his chosen lines of mathematical physics and astro-physics; therefore, in 1897 he withdrew from the school and engaged in the solution of certain problems.

In Boston in 1898 he read a paper, "Behavior of the Atmospheres of Gas and Vapor-Generating Globes in Celestial Space," before a meeting of the American Association for the Advancement of Science. An abstract was published in the *Proceedings* of the Association for that year.

In 1899 "Some Properties of a Gaseous Sun" appeared in the *School of Mines Quarterly.*

In 1901 the *Astronomical Journal* contained his article on "The Eruptive Energy of the Stars," which explained the generation of stellar atmospheres by subsidence of globes composed of a mixture of gases the molecules of which are equal in thermal capacity, but unequal in mass.

In the same year, in *The American Journal of Science,* was published "The Motion of Compressible Fluids," which set forth his discovery that equations of motion of compressible fluids have always two solutions representing two real and different motions of the fluid.

Mr. Davis died on November 7th, 1902, leaving a paper, nearly finished, in which are given the exact solutions of the equations for tidal waves, solitary waves, and sound waves.

Mr. Davis was elected an Associate of the American Society of Civil Engineers on June 3d, 1885. He was also a member of the American Association for the Advancement of Science, the New York Academy of Sciences, the New York Mathematical Society, and others.